RADIOLOGIC EXPLORATION OF
The Bronchus

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Foreword

Definitive and successful treatment of any disease depends to a great extent upon accurate diagnosis and precise localization. The more vital the organ, the greater is the importance of these determinations, and the need for accurate localization of the disease process is accentuated when cure depends upon surgical reconstruction or excision.

Treatment of certain thoracic diseases by surgery has been practiced for many years. Recently, however, great progress has been made in the technique of handling pulmonary tissue itself. Mass amputation of a lobe or of an entire lung with the aid of a tourniquet has been supplanted by a precise dissection of anatomical structures, separation of the healthy portions of the lung from the diseased portions, individual treatment of vascular and bronchial elements, and immediate restoration of function of uninvolved portions. In other words, surgical treatment of broncho-pulmonary segments calls for a plan of resection which may mean a bilateral lobectomy, pneumonectomy, or bilateral segmental removal. It becomes apparent, therefore, that careful studies and correct interpretation of findings should precede the institution of treatment.

Professor Di Rienzo's work on bronchography will interest clinicians, roentgenologists, and thoracic surgeons. Although the use of contrast media in the roentgenologic study of pulmonary disease has been accepted universally for many years, improvement in clinical bronchography, as practiced generally, is to be desired. For example, in the treatment of bronchiectasis, too often the first examiner has been satisfied with merely establishing the diagnosis. It has been a common experience of thoracic surgeons to be asked to treat cases in which a diagnosis of bronchiectasis has been made elsewhere by the demonstration of dilated bronchi in one or the other lower lobe after a small quantity of iodized oil has been permitted to run down into the trachea. This study may have been sufficient to establish the diagnosis but was wholly inadequate as a guide to the surgeon in planning the extent of the resection.

Some patients object to a second intratracheal injection, especially if the first is attended with discomfort. Therefore, in the interest of

economy of both time and expense, additional studies should be avoided. Extensive intrathoracic surgery can be carried out with greater safety if an interval of several days or a few weeks is allowed to elapse between the time of the installation of the oil and the operation. It is of advantage to wait until most of the oil is eliminated from the lungs, especially if there has been extensive alveolar filling. If possible, all information that bronchography can provide should be obtained at the first examination.

Professor Di Rienzo's book, based on wide clinical experience, fills the need for a comprehensive treatise on bronchography. The anatomy of the broncho-pulmonary segments is clearly reviewed. The importance of familiarity with all the components of the tracheobronchial tree is stressed. An entire chapter is devoted to the technique of installation and of fluoroscopic and spot photographic procedures. Numerous fine reproductions of bronchograms are shown, and the completeness of bronchial fillings, their clearness of outline, and the absence of overlapping and obscuring shadows all attest to the perfection of the technique. Separate chapters deal with the use of bronchography in chronic diseases of the lung, and the diagnostic value of clear contrast visualization of the bronchial pattern in each instance is repeatedly demonstrated. The work of Professor Di Rienzo will serve as a guide to medical students who intend to utilize bronchography in diagnosis and to physicians who wish to improve upon the technique and interpretation of their bronchographic studies.

Richard H. Overholt, M.D.

Boston, Massachusetts

Preface

The material collected in this volume was originally shown as an exhibit in connection with the Fourteenth National Congress of Surgery held in Buenos Aires. The many expressions of approval of our colleagues who visited the exhibition prompted us to finish the text which we had begun one year previously, and thus bring up to date a method of radiologic exploration of the bronchus, the importance of which has increased concurrently with the progress made in thoracic surgery We were influenced in this decision by the North American surgeon, Richard Overholt, to whom I had shown the chapters already prepared at that time, and who had made known to me his desire, and that of other surgeons and radiologists, that I should publish a volume explaining the technique and our experience with the contrast method of exploration of the bronchus In line with these suggestions, this volume contains practically nothing more

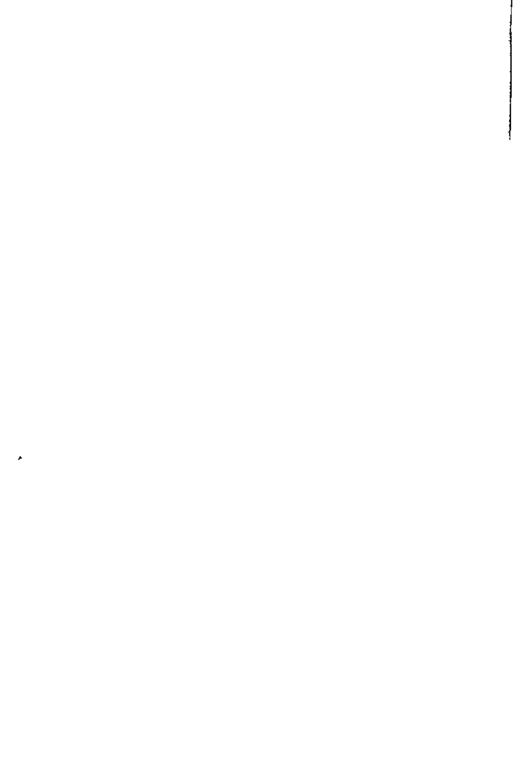
The book is the fruit of the united efforts of what might be termed a radiologic team. Each of us has put into it a maximum of effort I wish to mention especially the work of Dr. Antonio Boher and his son Robert, who took a prominent part in the selection of the technique, the preparation of patients, and the bronchographic studies Mr Luis Di Rienzo of the photographic department prepared very fine negatives and photographic reductions. My thanks are due also to my technical assistants, Rudy Schnabel and Victor Calou for their enthusiastic support, and to Miss Ada Ruiz Montes De Oca, who assisted in the bronchographic studies and the lay-out of radiologic material.

Dr Tomas De Villafane Lastra, Professor of Clinical Epidemiology, contributed not only the greater part of the material in this volume, but also his advice and encouragement, providing financial assistance and starting points for new investigations. For this reason, Professor Villafañe Lastra might be called the spiritual father of this work.

I also wish to express my thanks to my fellow clinicians in the Rawson Hospital of Cordoba and to Professors J. M Allende and T Castellano in the Cordoba University Faculty of Medicine and Surgery, who made possible the exploration studies of their patients.

S. Di Rienzo

Cordoba, Argentina
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The Bronchus

CHAPTER I

Embryology of the Respiratory Tract

Notwithstanding the great amount of investigation of this subject, many of its aspects are still obscure. Therefore, in presenting our schematic concept of the evolution of the respiratory tract, we shall confine our observations to established facts.

According to Policard, the embryonic evolution of the lung is divided into three periods, the first extending from the primitive state to the fifth month of intrauterine life; the second, extending through the sixth month of intrauterine life; and the third, from the sixth month of intrauterine life until birth.

First Period. A bud appears on the ventral surface of the entodermic intestine in the region of the pharynx when the embryo is

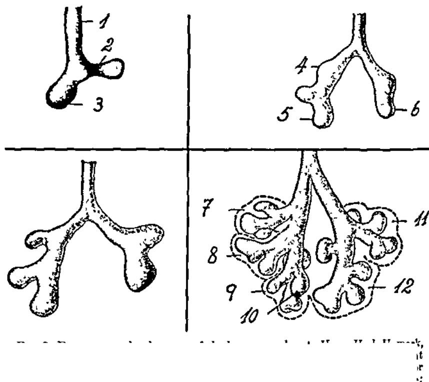


FIG 1 First stages of human breathing apparatus, according to Grosser, Heiss, and Arey A and B, frontal and lateral view in a 28 day embryo, C, frontal view in a 32 day old embryo 1 and 4, trachea, 2, lung bud, 3 and 6, esophagus

only 4.5 mm. long. The first outlines of the air ducts develop from that bud (Fig 1). Numerous branching entodermic tubes sprout from this evagination. They grow between layers of connective tissue, resulting in division into branches.

This whole outline is surrounded by a mesenchymal mass that originates from the mesodermic layer in the embryo; its ultimate use will be to provide the lung with all the parts except its epithelial and serous covering, the pleura, which is merely the visceral sheet of the mesoderm (Fig. 2).

In brief, during this period, there is a non-differentiated mesenchymal mass with a few capillaries surrounding entodermic tubes that grow outward and are arranged in layers on the inside, that is, a glandular outline.



and 12, left inferior lobe

A	5 mm embryo	30 days old
B	7 mm embryo	35 days old
C	8 5 mm embryo	40 days old
D.	13 5 mm embryo	45 days old

During this period, the tubes are lined by *cuboidal epithelium* and the lung is incapable of breathing.

Second Period. Although this period is the result of changes that begin in the fifth, and even the fourth month, we consider that it runs through the sixth month of intrauterine life. This opinion is based on the fact that at this point the picture becomes typical.

The bronchus and terminal bronchioles, the respiratory bronchioles and the alveoli have become differentiated. In fact, the walls of the future bronchus derive their cartilage, muscles and fibres from the

mesenchyma which, as we have seen, surrounds the entodermic outline. The epithelium becomes elevated and the definite character of the branches is apparent.

It may be said that the organization of the bronchus follows a characteristic transformation of the mesenchyma surrounding the epithelial tubes. It contains many capillaries (branches of the pulmonary artery), some of which project into the lumen of the bronchioles at this level, the cuboidal epithelium degenerates and falls off (Policard's desquamation), because the cells become filled with fat droplets. The process of bronchial lining must not be confused with the true phagocytosis that occurs in the mesenchyma surrounding the tubes.

The phenomenon of bronchial lining desquamation should not be considered as a *simultaneous* but as a *progressive* action in the lung

In brief, the lung appears to be a gland with its glandular ducts (future air cavities) separated by mesenchyma rich in blood vessels It is Dubreil's canalicular state.

There are no alveoli at this stage, but the lung is ready to function, making hematosis at the respiratory bronchioles and alveolar ducts possible, thanks to the growth of the capillaries.

Third Period. This stage initiates the formation of the alveoli. When and how are they formed?

It is difficult to determine just when their formation begins. We have already seen that they have not yet appeared in the sixth month according to the data available. We shall not go into the consideration of the numerous opinions given, as the problem is not within the scope of our purpose. We shall only give the generally accepted opinions.

It is a question whether as a consequence of desquamation, minute points of resistance are formed, through which the amniotic fluid passes into the mesenchyma to form the exacerbations where the alveoli are originated.

Rose is inclined to believe that the formation of the alveoli is not, as was formerly believed, the result of displacement of preexisting formations at the beginning of breathing, but rather the result of the production of cavities in the mesenchyma, due to the penetration of the amniotic fluid into the mesenchyma during fetal life. The rudimentary respiratory movements enlarge these cavities by increasing the tension within the fluid at each expiration.

According to this theory, at the moment of birth, the bronchioles and *air cells are already formed, and the only phenomenon of* importance would be the substitution of amniotic fluid by air by an unknown mechanism

The consequence of the formation of the alveoli is the formation and orientation of collagenous and elastic fibres. We say "as a consequence of alveolar formation" because this implies the beginning of the respiratory function.

To summarize—At the full term, the lung is formed; the bronchial epithelium has already changed its appearance (as we have seen at the sixth or seventh month); and the *air cells may not be considered a product* of breathing, but as existing before breathing takes place.

The lung is not evolved from a purely entodermic outline, with bulgings (future alveoli), spread out through the influence of the air, but is evolved from outlines: the entoderm (future air cavities) and the mesenchyma (future alveoli).

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CHAPTER II

Bronchial Histology

We do not pretend to write a complete and detailed chapter on bronchial histology. We wish only to summarize all the anatomical knowledge that the radiologist should bear in mind.

In this chapter we shall follow along the lines of classic works referring to large bronchi, and concerning small bronchi and lung acini we shall be guided by the opinions of Policard and Miller [1]

Classification of Bronchi

Many histologic classifications of the bronchi have been made, but the one that has been found most useful is undoubtedly that of J. Renaut, as follows:

I. *Bronchi*. characterized by a diameter of more than 1.5 mm We may classify them as· large bronchi (also distribution bronchi) and small bronchi (or interlobular).

II *Bronchioles* their calibre is less than 1 5 mm We may still consider as bronchioles the following

   a) *Bronchioles proper termed* about 1 mm in diameter.
   b) *Terminal bronchioles*, of 0.5 mm. calibre.
   c) *Respiratory bronchioles* and *alveolar ducts*.

We must explain that this classification is based not only on the diameter of the bronchi, but also upon the histologic differences they present when they have acquired that diameter.

Histologic Constitution of the Bronchus

The constituents of the bronchus wall may be divided into two groups.

1) Interior. the mucosa, consisting of *epithelium, elastic connective tissue corium* and a *muscular layer*.

2). Exterior. A *fibrous sheath or peribronchus* that fuses with the

[1] A Policard Le Poumon Masson et Cie Paris, 1938 W S Miller The Lung Charles C Thomas Second Edition, 1940

periadventitia of the satellite blood vessels and contains, in the bronchi of a certain calibre, *cartilage* and a *gland* called the bronchus gland

The bronchus wall, therefore, presents peculiarities according to the individual type.

We shall begin with the large bronchi and end with the alveoli, and explain their differences.

I. **Bronchi** (*more than 1.5 mm. in diameter*).—The *mucosa* of the *large bronchi* consists of epithelium and dermis. The epithelium, like that of the rest of the breathing apparatus (up to the nasal cavities), is of the cylindrical type.

These epithelial cells belong to the common type of *ciliated cells*. In the opinion of some authors, their disposition is multi-stratified; while others maintain that such a multistratification is only apparent depending upon the height at which the nucleus is situated.

Furthermore, *goblet cells* are found (autonomous glands or simple cylindrical derived cells) in different stages of secretion.

FIG 3 Transverse section of a large bronchus (Bohm and Davidoff); 1, ciliated cylindrical epithelium, with basal membrane; 2, elastic fibers cut transversely, 3, glands, 4, membrana propria; 5, cartilage rings, 6, peritracheal connective tissue

On the borderline of the dermis we find the *basal cells* that originate those which are to replace the desquamated cylindrical cells. Mitotic figures are frequent in them.

The whole of the epithelial lining is supported by a layer called the *basal layer*.

The dermis extends to the muscular layer (Fig. 3).

The corium is a fibrous connective tissue, having numerous *blood vessels* and *histiocyte* cells; although, undoubtedly, its characteristic element is *elastic tissue*. This tissue is found next to the basal layer, forming a very dense network that Letulle has called "*interior elastic limitant.*" Fibres leave this limiting elastic layer, piercing the whole

of the corium, sheathing the muscular, cartilage and glandular formations, and ending in the peribronchus, where they form the *external elastic boundary* Therefore, the elastic formations of the corium and the peribronchial layer should be considered as one and the same thing (Fig 4).

There remains the muscular layer of the mucosa (according to the division we have made of the bronchial wall). This layer belongs to the *non-striated type of muscle*, and in the bronchi (of more than 1.5 mm. diameter) it has a circular disposition outside the corium.

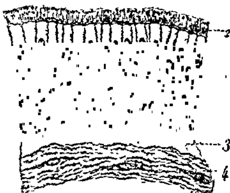


Fig 4 Perpendicular section of human tracheal mucosa (according to Tourneux), 1, epithelial cells, 2, vibrating cilia, 3, mucous membrane, 4, corium mucosa

Peribronchial Sheaths.—This layer is of particular importance in the bronchus of 1.5 mm. diameter where it reaches its maximum development.

In general this layer is composed of.

1). A system of fibres which appear as *collagenous bundles* or concentric lamellae parallel to the axis of the bronchus. This disposition of lamella is of great importance, as they form channels for lymphatic circulation. They also play a very important mechanical role, holding the bronchi and vessels together at the same time permitting independent movement.

2) *Elastic formations* that, as we have seen, are part and parcel of the mucosa. In the peribronchus these formations reach a development not observed in the dermis.

3). *Glands*. The bronchial cartilage lodged in the peribronchial sheaths is of the hyatine type, and in the type of bronchus we are considering is ring shaped and sheathed by the elastic fibres of the corium.

Small or Interlobular Bronchi.—The difference between these and the large bronchi is very slight and is related mainly to their peribronchial sheath, which is thinner, having its greatest thickness on

the side of the blood vessels. The cartilage is *no longer ring shaped* but assumes a circular form. The glands become more rudimentary (Fig. 5). *The other coats are thinner.*

II. **Bronchioles** (*of a less diameter than 1.5 mm.*)

a) **Bronchioles proper** (1 mm.).—In this type the cylindrical epithelium of the *mucosa still contains* goblet cells; the corium mucosa becomes thinner and loses its elastic layer, or internal boundary. *The musculature acquires great strength* and at this point reaches its greatest development. Its horizontal fibres *are joined by oblique fibres* that assure perfect continuity.

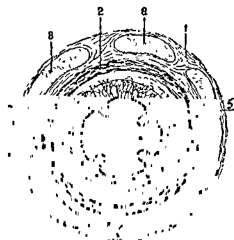


Fig. 5. Transverse section of a bronchiole

8, cartilage

The complete absence of cartilage is clearly evident in the *peribronchial sheaths. The elastic fibres that have grouped themselves around the muscle projecting upon those sheaths* form an external boundary that diminishes in importance as *the* bronchus diminishes in diameter.

The glands are lacking in general and the entire peribronchial layer has become thinner.

b) **The terminal bronchioles,** which are the continuation of the bronchioles proper, are of similar construction, this being the last segment to show, as a whole, *the typical bronchial constitution.*

And so we come to the last bronchial segment, resulting in general from the dichotomous branching of the terminal bronchiole and the *respiratory bronchiole.*

c) **The respiratory bronchioles** belong to the mesenchymal system of the lung. Their diameter is larger than that of the terminal bronchioles. Their epithelium is still cylindrical, ciliated, but the *goblet cells have disappeared* *The muscular system* remains, although diminished.

After the first division of this bronchiole, which we may call a

first order bronchiole, we pass to a *second order bronchiole* characterized mainly by its lower and non-ciliated epithelium. Furthermore this epithelium is present only on the side on which the pulmonary artery is situated. On the opposite side we see alveoli opening out.

After a further division we come to the *third order bronchioles* where we find the alveoli completely formed and only a thin layer of cuboidal epithelium remaining.

Two points remain to be explained. the muscular layer, and the connective tissue. We may ask: "How does the lung grow? Is it by enlargement of preexisting cavities or are new ones formed? Or do both processes take place?" Let us see. At the time that these new alveoli are formed in connective tissue as under the pleura or in the interalveolar layers according to Rose, the alveolar ducts and the preexisting thin-walled alveoli little by little take on the appearance of respiratory bronchioles due to the proliferation of connective tissue and non-striated muscle, or rather, to a mesenchymal growth, from which cuboidal epithelium later extends

Hence we may deduce that the respiratory bronchioles are transitional stages between the primitive alveolar duct and the terminal bronchiole. This explains why the alveoli that open into these respiratory bronchioles are smaller than the others and why in an aged person, the respiratory bronchioles have disappeared almost completely. In short, the formation of alveoli has been delayed, but not the formation of bronchioles.

With this fact in mind, we may ask whether it is correct to call this stage "alveolization." Policard calls it "bronchiolization," and we believe that, based on the explanation of the facts, it is the most exact term

Alveolar ducts· Beyond the respiratory bronchioles (which are bronchioles on account of their rudimentary epithelium), are the alveolar ducts. These ducts have, as a fundamental characteristic, complete "alveolization," and have no walls in the strict sense of the word

In a lung section we find lung parenchyma filling the spaces left by the bronchovascular tracings All this is a confused mixture of respiratory bronchioles and alveolar ducts.

To get an exact idea of this parenchyma we have deliberately left the description of the connective tissue and the formation of muscles and bronchioles until this point because we have observed in the

respiratory bronchioles a fenestrated non-striated muscular layer and an *adventitia that* contains collagenous and elastic elements.

The muscular layer (Fig. 6), in the bronchioles forms a sphincter for the alveoli just as do the *elastic and collagenous* fibres. The latter constitute what old authors used to call cervical fibres.

All this, on passing into the alveolar duct, which as we already *mentioned* has no proper wall, forms that very typical zone called the

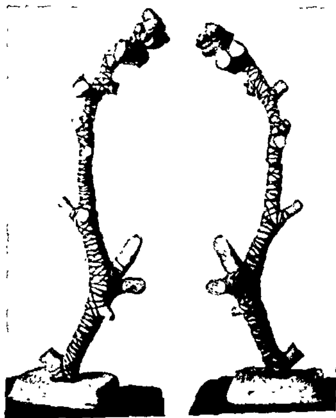


Fig. 6. Muscular layer in the bronchioles—Taken from W. S Miller, The Lung, Charles C Thomas

alveolar mouth The elastic fibres, that, as we should emphasize, are fewer in the peribronchial sheath, are responsible (when well stained) for the tracings that show the course of the alveolar ducts and respiratory bronchioles.

In a word, we find in the lung parenchyma *muscular, elastic, and collagenous fibres.*

Alveoli

Letulle gives the following definition for the alveolus. "It is the specific and irreducible element of the lung consisting in a balloon-like bubble, more or less spherical, which opens into the air duct" We give this definition on account of its clearness, yet it must not be taken literally, as the form of the alveolus is polyhedral Therefore, in a section, the alveolus (if the lung is in its normal condition) presents a polygonal contour, not a circular one.

The diameter of these alveoli varies from 0 100 mm. to 0.150 mm., corresponding to those opening into the respiratory bronchiole (these are the smallest as we previously stated) and to 0 500 mm. in those into which the alveolar ducts open. It is very difficult to give an exact figure for the number of alveoli. Policard says there are from three to four hundred million covering a total surface of *50 square metres* of the lung surface.

The alveolar wall is formed by a membrane in which we can distinguish fibrous networks composed of elastic, collagenous, and reticuline fibres (which can be recognized by their chemical and physiological behavior).

The membrana propria of the alveolar wall always assumes a homogeneous morphologic appearance. It seems to us to be fundamentally formed by *connective tissue.* But we have said that it is *homogeneous;* the fact is, we observe neither pools nor lymphatic vessels in it

Policard compares the alveolar cavities to connective tissue pools (the walls of which are constituted by these membranes), but full of air. Nevertheless, these membranes do not present the characteristics of collagen; they do not expand with the addition of acids nor do they jell when heated; they resemble rather reticular fibres. It would seem that between the membranes and intercapillary fibres there are no precise limits, but that there are transitions.

Elastic fibres. These are found where the alveoli open out, together with elastic and muscular fibres; but these fibres really belong to the peribronchial membrane and not to the alveolar system proper.

In the alveolar walls we observe fine and not very abundant elastic fibres In this connection it is convenient to refer to Orsos, who differentiates *respiratory fibres* (forming part of the alveolar wall) from *circulatory fibres* (their disposition is in a peri or intercapillary network).

Among the respiratory fibres we find some that radiate over one or several alveoli, reaching a great distance and forming long elastic trajectories within the parenchyma. These trajectories, considered in the whole lung, *form real supportive lines that indicate the direction in which more or less strong traction is exerted.*

Collagenous fibres. Their existence has been denied by Von Eber. In reality they are not very abundant.

Reticuline fibres. These are very abundant in the lung (where they seem to play a supporting role). They are found surrounding the capillaries and in the alveolar wall itself.

The network of precollagenous fibres surrounding the capillaries is arranged in two layers. The first is formed by fine, ring shaped fibres just outside the capillaries and the second by stronger fibres separated from the capillaries by a space in which the vessel may be subjected to variations in volume and direction. Finally, this second layer forms a sort of reticular adventitia to the capillary, within which there are some fan-shaped fibres that join those of the alveolar wall.

In general the fibres proper of the elastic wall accompany the elastic and collagenous fibres.

Alveolar lining. The alveolar lining has long been considered as consisting of epithelium in which we find non-nucleated plates extending between the cells.

In 1926, Policard clearly demonstrated that such non-nucleated plates do not exist.

It may therefore be accepted that the alveolus has a discontinuous lining and that the cells are always situated between the capillaries.

These cells are classically considered as epithelial; nevertheless several facts are in opposition to this opinion.

These facts are:

First, the alveolar lining adapts itself to all the alveolar irregularities, and its cells give off pseudopods; for this reason it cannot be compared to the epithelium, as the most differential bronchial cells are cuboidal and in general present a more rapid appearance

Second, these cells absorb the vital dyes injected into the blood and there is a flocculation of the electronegative colloids. This is one of the surest methods for recognizing the histiocytes, as it never occurs in the bronchial epithelium.

Third, phagocytic properties are peculiar to alveolar cells. These processes are best observed in intra-alveolar cells that are closely

related to lining cells. The origin of these cells may be either the blood or the alveolar lining. It was thought that their origin could be found in the blood, as mitotic figures are rarely found in the lining. What really happens is that there is a diapedistis of elements that, after several transformations, constitute these intra-alveolar monocytes

Westhues has an interesting experiment consisting of the injection of India ink into a *lung after its perfusion*. A part is then fixed and another is kept half an hour in the oven with isotonic serum. At the end of the experiment it was found that in the first portion there was no phagocytosis, but in the other portion the alveoli enclosed cells filled with India ink. As there is no blood supply, alveolar cell multiplication is to be considered

As may be seen, these cells appear to have a two-fold origin, one being the division of the alveolar cells, and the other, elements thus formed, exogenous phagocytic particles, as carbon, bacteria, fat bubbles injected into the trachea, lipiodol, and so on

Fourth, *metabolic activity* The alveolar cells take part in the metabolism of certain substances like fats, even when in their normal state, these cells may also play a role in the metabolism of cholesterol, of sugar, amino acids and polypeptides.

From these observations we conclude that the lung may be considered as a *constituent of the reticuloendothelial system*.

		Bronchi			Bronchioles			
		Large		Small or interlobular	Bronchioles proper	Terminal	Respiratory	Alveolar ducts
Mucosa	Epithelium	Ciliated cylindrical Goblet cells		These coats become thinner	Ciliated cylindrical goblet cells	Ciliated cylindrical goblet cells	Loses its cilia, flattens, loses goblet cells	They have no proper wall and the elements are disposed like *those of the alveolar walls of* the respiratory bronchi
	Corium	Fibro-connective histiocyte type cells, elastic tissue predominant (internal boundary)			Becomes thinner losing internal boundary	Same as bronchioles proper	Connective tissue and very much reduced	
	Muscle Layer	Smooth muscle outside the corium			Relatively very powerful	Disposition similar to bronchioles proper	Aspect of a fine fenestrated mesh alveolar sphincter	
	Fibrous System	Has its greatest growth in this *type*	Collagenous fibres Fibrous laminae concentric and parallel to bronchus		These coats become thin	Remain more or less the same	These fibres form those of the alveolar opening	
Peribronchial Sheaths	Elastic Formations		Not as strong as in the chorion (*external boundary*)		Still exist but the layer is thinner	Surrounds the muscle forming an internal limitant	They are those classically called fibres of the cervix	
	Glands		Sero mucous secretion	More rudimentary	Lacking	Lacking	Lacking	
	Cartilage		Hyaline type ring segment	Circular tracings	Lacking	Lacking	Lacking	

CHAPTER III

Anatomy of the Bronchus

The distribution and anatomical position of the bronchial branches have been well explained by means of *sections, dissections* and *casts*. The numerous anatomical and radiologic investigations carried on for the purpose have nevertheless not been sufficiently complete to permit a classification of the bronchial branches that would be acceptable to the medical profession in general

Anatomists classify the bronchial trunks according to the direction of their branches and their relation to the pulmonary artery, the radiologists, according to their relation of these trunks to their incisural planes, and the surgeon according to surgical possibilities. We believe, notwithstanding opinions of the anatomists to the contrary, that the surgeon's criteria should take first place.

Without going into a discussion of these various opinions, we propose to consider bronchial architecture from the anatomical and surgical point of view, in the cast, and afterwards from the radiological and surgical point of view by means of *bronchography*.

Bronchial Casts

In our opinion, bronchial architecture should not be studied in the cadaver and certainly not in a body that became rigid in dorsal or ventral decubitus For various reasons observations obtained in casts of the cadaver do not agree with those found in the living body.

First, it is necessary to know the *cause of death*, for an extra-bronchial factor may have deformed the bronchial architecture, giving us pathologic configurations that may be mistaken for normal For instance, in cases of death from heart failure, the bronchial fork opens up, the left main inferior bronchus becomes arched and the right and left ventral branches rotate outward. The reverse is true in death from lung fibrosis, in which case the lung fork closes and the branches fold in.

The position in which the body becomes rigid is important because the bronchial branches present deformities accordingly. It is common to note in classical anatomical works and drawings of the

bronchi, that the medium sized and fine branchings appear to form an arch that bends backwards. This is nothing more than a cadaveric *deformity and is not found in patients explored with contrast media.*

Bronchial casts express only the canalicular aspect of the cadaveric bronchus, and although this may be really useful in *beginning the* study of bronchial architecture, it is insufficient for a detailed study of the bronchi.

The only procedure that can give us complete information regarding the morphology, architecture and dynamism of the bronchus, is *bronchography* in the living person. This information cannot be questioned, for the architecture is true and the dynamism complete. A record of the various filling stages is possible by using a technique *that is without complications, and radioscopy provides complimentary* information.

We have made bronchograms from the cadaver; we have x-rayed bronchial casts obtained with opaque pastes, and after these casts have been extracted after macerating the lung, we have photographed *them These procedures served only to convince us that efforts to* reach the depth of bronchial knowledge must be directed toward the practice of bronchography as the only means of progress.

For this reason we shall briefly report the information provided by the bronchial casts, and report in detail our findings based on bronchog*raphy in living patients.*

We shall first point out the distribution and situation of the various branches and sub-branches of the main bronchus of each lung.

Front View of the Complete Bronchial Cast

The bronchial tree cast, obtained in the cadaver with medium penetration of the injected paste, shows us the aspect of the bronchial lumen, which is useful for a knowledge of the number and approximate situation of the *bronchial ramifications as we have stated previously,* these findings should not be taken completely for granted, for in addition to tissue retraction, deformities in the course of the bronchi occur in the cadaver that do not exist to the same degree in the living body.

The cast is useful for a general knowledge of the distribution of the bronchial branches, and this implies a stereoscopic interpretation. It is as useful as seeing a cast of the stomach of the cadaver, which roughly indicates its relation *to the neighboring organs,* but which is

very different from findings obtained in radiologic examination of patients.

Figure 7 represents the front view of a bronchial cast from a cadaver that acquired rigidity in dorsal decubitus The cause of death was myocarditis, and the patient died in asystolia, the expansion of the heart caused the displacement of the trunk of the

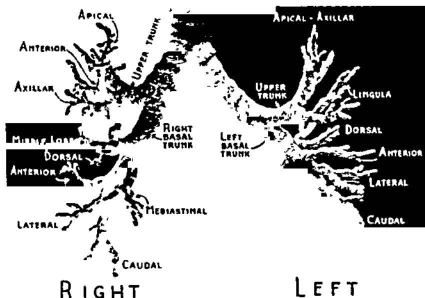


Fig 7 Front view of a bronchial cast (patient died in asystolia) (This cast was taken by Osvaldo Suarez in the Cordoba Institute of Anatomy directed by Professor H Fracassi)

lower left lobe and the outward rotation of the branches surrounding the heart.

We believe that the penetration of the paste should not go farther than the beginning of the sub-branches, for they are the only ones that keep the same position. The finer branchings present considerable difficulty, for the bronchial tree varies greatly in its form and distribution

In the bronchial cast seen from the front (Fig 7), the branches directed outward are very clearly shown as are those that are directed downward and upward but the real size of those that are directed

forward or backward is not made evident. However, we are concerned here only with a brief study of *bronchial projection*, for we shall consider it in detail when we study the bronchographic picture. Let us begin with *bronchial segmentation*, lobe by lobe.

Right Lung

a) **Superior lobe.**—Two to three centimeters from its origin, the *primitive right bronchus originates the trunk or superior lobe bronchus*, having a general outward direction. Immediately (at a distance of 1½ cm., more or less), this trunk originates three branches which we shall call, on account of their direction, *anterior, apical and axillary.*

These branches originate others that are interesting to know, for this knowledge will help us to locate broncho-pulmonary pathologic processes with greater precision.

The *anterior* branch, in turn, subdivides into two branches; one *internal* and the other *external*, both on a very similar plane. *The apical* branch originates an *anterior* and *a posterior* branch. The *axillary branch (improperly called posterior, for it has not this direction)* originates a *posterior ascending* branch and the *axillary* branch which follows the general direction of the main trunk of the upper lobe.

b) **Middle lobe.**—The main bronchus of the middle lobe arises from a trunk common to this lobe and the lower one. After a course of about 1 to 1½ cm. the main trunk of the middle lobe, directed forward, outward, and downward, divides into two large branches: the *upper anterior* and the *lower posterior. These branches, in their* turn, give rise to others that go forward, following the superior incisural plane, and backward and outward seeking the large incisura.

c) **Inferior lobe.**—The common trunk for the lower and middle lobes almost simultaneously originates the middle lobe trunk anteriorly and a first dorsal branch that belongs to the lower lobe. For this reason we are justified in pointing out that the common trunk divides into three immediately *after it originates. We deal with this* later on, in referring to bronchial classification from the surgeon's point of view.

The lower lobe trunk then continues its course downward and backward, giving out *anterior, lateral*, and *dorsal or posterior branches.* Toward the middle line it gives out *a mediastinal branch* that is of variable importance.

Projection of the Whole Front View

The image that the cast of the bronchial tree presents is confusing in frontal position, but very clear in transverse position.

This confusion is less for the upper lobe than for the other lobes. An intermediate position that allows a very complete analysis of the different branches is the *left anterior oblique* one for the right lung, and a *right anterior oblique* for the left lung. Nevertheless it is the *transverse* position that best illustrates the direction of the branches, giving information in the bronchogram regarding the location of disease processes and serving as a guide to the best methods of surgical attack.

Figure 8 shows the bronchial cast seen from the right side, having the left branchings covered. In this position the anterior, posterior, ascending and descending branches stand out. The branchings that are directed outward and inward are not well shown as they are of least importance.

In the right upper lobe the *anterior* and *apical* branches are clearly evident. From this branch shoot out the *anterior* and *posterior* sub-branches that are plainly visible in this position.

The *axillary* branch is visible only in the posterior sub-branching, for the axillary trunk is perpendicularly directed with regard to the photographic objective.

The *middle lobe trunk* is plainly visible although the upper inner and lower outer sub-branches are not clearly identified.

The ventral and dorsal branches of the lower lobe, and even the mediastinal branch are visible along the whole length of their course.

Left Lung

a) **Upper lobe.**—The main trunk of the left lung is frankly curved toward the apex. After a 4 to 5 cm. course, it originates the two main bronchi of the supero-anterior and postero-inferior lobes

Four principal branches shoot out from the upper lobe bronchus. an *apical*, an *anterior* and *axillary*, and an *anterior descending* branch (or bronchus of the lingula lobe), which is the homologue of the right middle lobe trunk. An *internal* branch and another *external* or *axillary* branch shoot out from the *anterior ascending* branch. The *anterior descending* or *lingula lobe branch* gives off two important branches. the *superior external* and the *inner forward* branches.

b) **Lower lobe.**—The main bronchus of the left lung, *after giving* off the bronchus for the upper lobe, continues its *downward, back*ward course, immediately originating ventral and dorsal branches.

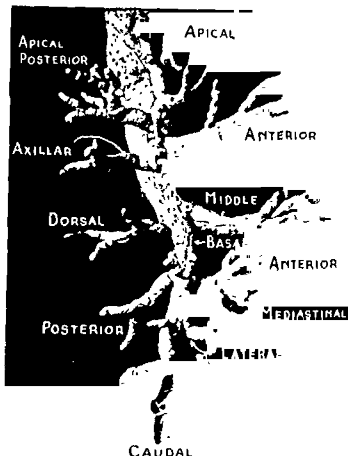


FIG 8 Right lateral view of bronchial cast The left side has been covered to avoid superposition of images We can clearly see the anterior and posterior as well as the ascending and descending branches (Cast made by O Suarez in the Cordoba Institute of Anatomy directed by Professor H Fracassi)

It is important to note that the first dorsal branch may arise at the same level as the first ventral and, as happens in the right side, the former usually constitutes the central bronchus of an independent lobe.

For this reason, the first segmentation of the main lower bronchus is also trifurcated, constituted by a *dorsal bronchus*, a *ventral bronchus* and a *basal bronchus* From the last named, second order ventral and dorsal bronchi continue originating.

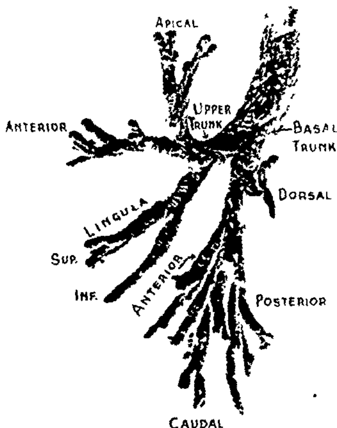


FIG 9 Lateral view of left lung showing the upper lobe branches and inferior lobe branches The right side has been covered (Cast made by O Suarez in the Cordoba Institute of Anatomy directed by Professor H Fracassi)

A mediastinal branch homologous to that on the right side also exists, and anterior and posterior branches follow along the cardiac and mediastinal surface of this lobe.

Transverse Position View

In lateral view of the left lung (Fig. 9), the apical, anterior axillary and anterior descending branches are easily identified for they do not overlap. *The sub-branches that they originate may also be seen.*

The lower lobe branches, anterior or ventral as well as posterior, are visible along their whole course.

Purely Anatomic Classification

Among the modern anatomists who have given a useful classification based on a special study of this subject, we must give due importance to *Professor H. Fracassi, Director of the Cordoba Anatomical Institute.* Fracassi's proposed classification is supported by an analysis of the numerous bronchial casts that have been obtained *after taking precautions to prevent the cadaveric deformities we* have mentioned.

Fracassi calls the fundamental main trunks *bronchi,* their segmentations, *bronchioles* and the branchings of the bronchioles, *bronchiolites.*

This anatomist proposes considering bronchial divisions as follows:

According to him, the *right* bronchus is the one that starts at the trachea and continues until it has originated the terminal branches of the lower lobe. Similarly he lists the *left* bronchus which is the one that starts from the trachea and ends in the final branchings for the lower lobe. The designations of other authors, namely, *intermediate* or *basal* bronchi are not accepted in this classification. Fracassi's *bronchial divisions are as follows:*

The right bronchus gives out a first collateral branch from its anterior surface, the *upper lobe bronchus* which divides into three branches—*superior, anterior* and *posterior* (Fig. 10).

Farther on, the right bronchus, continuing as such, gives out from its anterior surface a second collateral—the *middle lobe bronchus*—that divides into two branches—*upper external* and *inferior internal.*

Continuing its course, the inner surface of the right bronchus originates a fourth collateral, namely, the *infra-cardiac lobe bronchus,* which ends up in two branches—*posterior-inner* and *anterior-outward.*

At this level the right bronchus ends, continuing along its terminal surface as the inferior lobe bronchus, which in its turn gives out three terminal branches—*anterior, middle and posterior.*

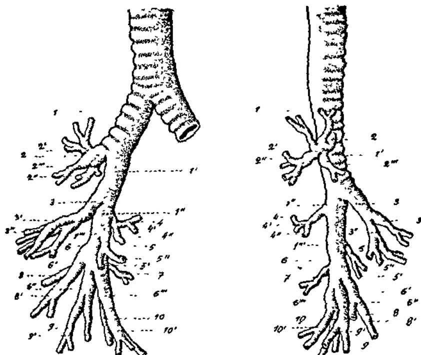


Fig 10 Drawing of an anatomical cast made in the Cordoba Institute of Anatomy

1, right bronchus, 1', 1'', right bronchus
2, superior lobe bronchus, 2', superior bronchiole, 2'', posterior bronchiole, 2''', anterior bronchiole
3, middle lobe bronchus, 3', superior external bronchus, 3'', inferior internal bronchiole
4, posterior lobe bronchus, 4', internal bronchiole, 4'', external bronchiole
5, infracardiac lobe bronchus, 5', anterior external bronchiole, 5'', posterior internal bronchiole.
6, inferior lobe bronchus, 6', internal bronchiole, 6'', middle bronchiole, 6''', posterior bronchiole
7, lower lobe dorsal branch
8, external bronchiole, 8', internal bronchiole.
9, anterior bronchiole, 9', posterior bronchiole
10, external bronchiole, 10', internal bronchiole

The *left bronchus* behaves in the same manner, except that the upper lobe and the middle lobe bronchi originate from a common trunk, situated on its anterior surface and at the level of the point of origination of the right middle lobe (Fig 11).

The *infra-cardiac lobe bronchus* does not originate directly from the left bronchus, as it should if it were identical with the right homon-

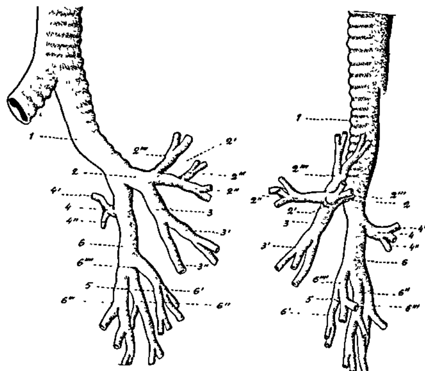


Fig 11 Drawing of an anatomical cast made in the Cordoba Institute of Anatomy

1, left bronchus; 1', left bronchus
2, common bronchus for the superior and middle lobes, 2', superior lobe bronchus; 2'', anterior bronchiole, 2''', posterior bronchiole; 2'''', superior bronchiole
3, middle lobe bronchus, 3', superior external bronchiole; 3'', inferior internal bronchiole
4, posterior lobe bronchus, 4', internal bronchiole, 4'', external bronchiole
5, infracardiac lobe bronchus
6, inferior lobe bronchus, 6', anterior bronchiole, 6'', middle bronchiole; 6''', common lobe for the infracardiac lobe and anterior bronchiole

ymous bronchus, but originates from the anterior division branch of the lower lobe bronchus, which for that reason we shall call the *common bronchus for the infra-cardiac lobe and the anterior bronchiole.*

Classification of the Bronchial Branches from the Surgeon's Point of View

For surgical needs, especially for ectomies, the anatomical classifications we have just mentioned are not the most useful, for surgical sections are not always of a complete lobe or of only one lobe but may be partial section of one lung lobe or more than one.

For this reason some thoracic surgeons have proposed more suitable

classifications, keeping in mind not only the branches of the known normal lobes, but also the anatomical possibilities of following along cleavage planes and separate new lobes Furthermore these classifications take into consideration the surgical difficulties that arise in lobectomies.

The modifications proposed by surgeons concern principally the right side and the designation of the branches that originate from the main trunk for the middle and lower lobes.

As we have pointed out, the right main bronchus, after it has given off the bronchus for the upper lobe, continues a course that is designated the *common trunk* for the middle and lower lobes. In reality, this main trunk for both lobes, after a run of a few centimeters, *forks into three* (Fig 12), and originates anteriorly the main trunk of the middle lobe, posteriorly, the first dorsal branch of the lower lobe; and downward, a trunk from which all the dorsal and ventral branches shoot later. This drawing demonstrates the difficulty in extirpating the whole lower lobe, when the first dorsal branch of this lobe originates directly in front of, or even what is more difficult, above the middle lobe. In these cases, a ligature on the anatomic hilum of the lower lobe (Fig. 13) will certainly cause the obstruction of the main trunk of the middle lobe. On the other hand, if the ligature can be placed under the first dorsal branch, this inconvenience will be avoided and a conservative surgical procedure may be carried out.

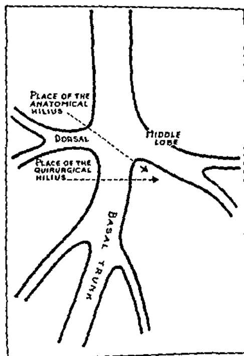


FIG 12 Sketch showing the trifurcation of the common bronchus and the position of the anatomical and surgical hilum of the lower lobe Lateral view

For these reasons Adams and Davenport[1] suggest the following classification for the right lung:

Right bronchus	Upper lobe bronchus	Anterior	Internal
			External
		Axillary	Anterior
			Posterior
		Apical	Anterior
			Posterior
	Intermediate bronchus	Dorsal bronchus	Internal
			External
		Middle lobe bronchus	Superior
			Inferior
		Basal bronchus	Anterior inner
			Anterior external
			Posterior inner
			Posterior external

On the *left side*, for surgical and anatomical considerations, we shall regard the descending anterior branch of the upper lobe as the branch of a third lobe, for very frequently an incisural plane is found that makes the territory ventilated by this branch independent of those of the upper and inferior lobe. This third lobe, called the *lingula* lobe, may be the only one involved and its main bronchus may be dissected at its hilum without affecting the rest of the upper left bronchus.

Likewise, the main bronchus of the lower left lobe, directly after it begins its course, originates two branches of equal importance,

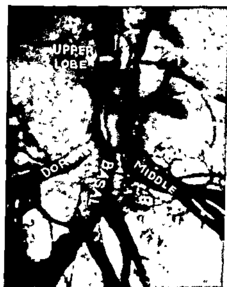
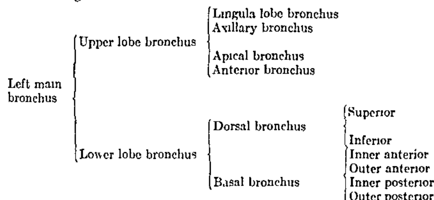


FIG 13 Bronchogram showing what has been pointed out in preceding sketch

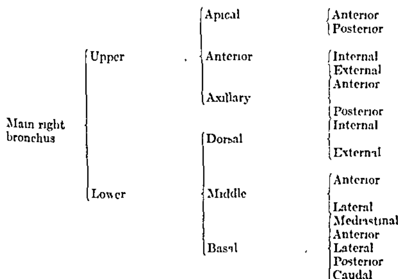
[1] R Adams and L F. Davenport "The technic of bronchography and a system of bronchial nomenclature," J A M A 118: N. 2, 1942

namely, the *dorsal* (1st dorsal according to the anatomists) and the *basal*, which later originates all the remaining dorsal and ventral branches.

Adams and Davenport suggest the following classification for the left lung:



The following is our suggested classification for bronchial arborizations:



		Apical	
	Upper	Axillary	Anterior
			Superior
		Lingular........	
			Inferior
			Superior
Main left bronchus		Dorsal	
			Inferior
			Mediastinal
	Lower		Anterior
			Lateral
		Basal...	
			Posterior
			Caudal

As we consider it of great practical interest, we shall mention the classification proposed by Jackson and Huber.[1]

RIGHT LUNG		*LEFT LUNG*	
Lobes	*Segments*	*Lobes*	*Segments*
	Apical	Upper Division	Apical posterior
Upper	Posterior		Anterior
		Upper	
	Anterior		
		Lower Lingular Division	Superior
	Lateral		
Middle			Inferior
	Medial		
	Superior		Superior
			Anterior-medial
	Medial basal		
Lower		Lower	
	Anterior basal		Basal
	Lateral basal		Lateral basal
			Posterior basal
	Posterior basal		

Roentgenologic Projection

We shall not study the roentgenologic projection of the opaque bronchial tree in the cadaver, for it is of no practical interest. We

[1] Dis of Chest July–August, 1943

shall describe only what occurs in the living organism, as it is in the living patient that this knowledge will be applied. The difference between *roentgenologic projection* in the cadaver and in the living body is significant. For reasons previously mentioned, it is not possible to obtain from the cadaver useful knowledge for everyday practice, even though thorough knowledge of anatomy is indispensable here, as in any study carried out in the human organism.

Radiologic study in the living organism gives us a complete picture, not only of the conformation and segmentation of the bronchial tree, but also of its *dynamism*, which we consider just as important as its anatomical characteristics. Moreover, exploration in the living organism can be done rapidly and may be carried out in very many cases while cadavers having a bronchial tree suitable for exploration are rarely available and exploration must be carried out slowly, overcoming difficulties that do not repay the results obtained.

Right Lung—Frontal Projection

1) **Upper lobe.**—The various branchings pointed out in the description of the bronchial tree are easily identified in the bronchogram, but we must not forget that we have obtained only *photographs* of the cast and that from now on we are going to describe *radiograms.*

In frontal projection, the three main branches corresponding to this lobe are clearly evident; namely, the *apical* branch directed upward, the *axillary* directed outward, and the anterior, projected towards the base. In Fig. 14, we observe the projection of the upper lobe bronchi, completely filled. Here the primary branchings are clearly shown, but the fine branchings of the *apical* and *axillary* bronchi are absent, because a pathologic process obstructs the progress of the opaque medium

Although it is true that in this position the projection of a branch overlaps those of other lobes, this will not be confusing for those who have some knowledge of bronchial distribution. Furthermore, the difficulty of obtaining a good profile film of this region, makes it necessary that the knowledge of frontal projection be thorough.

b) **Middle lobe.**—The study of the projection of the middle lobe branches offers no difficulties. In frontal position, the two main sub-branches, that is, the anterior superior and the posterior inferior, are directed downward and outward (Fig. 15). The positions in which to



Fig 14 Filling of superior right lobe only showing the frontal projection of the bronchial tree 1, apical branch; 2, axillary branch; and 3, anterior branch



Fig 15 Middle lobe branches projected in frontal position.

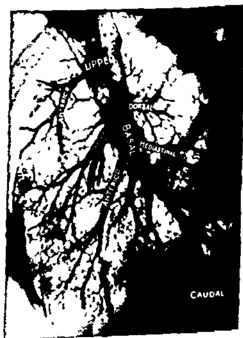


Fig. 16 Right lung bronchi seen in anterior left oblique.

observe them are the *anterior left oblique* and the *transverse*. In the anterior left oblique, the main branch and sub-branches are evident along their whole course.

c) **Lower lobe.**—The branchings of the main lower lobe bronchus



Fig. 17. Frontal roentgenogram obtained [illegible]



[illegible] and the spasm in an accessory branch of the lower lobe.

are superimposed upon one another in frontal position, due to the fact that all the branches have a posterior or anterior direction, as may be observed in Fig. 15. To bring them into view it is necessary to return to the transverse position or to an intermediate one, the left anterior oblique. In this position, as we see in Fig. 16, the ventral, lateral and dorsal branches are clearly evident in their mutual relationship.

Whole Frontal Projection

Simultaneous filling of all the branches, superior, middle and inferior, results in a rather confused picture. If the early images of canalicular filling are registered, it is not yet possible to identify the lobe to which they belong and what direction they follow. If, on the other hand, we have only one radiogram showing the final phase, when the innumerable small branches have become opaque, then the difficulties for interpretation may be overcome only by those who have a thorough knowledge of bronchial anatomy.



Fig 19 Complete opacity of the right lung bronchi

In Figs. 17 and 18, are shown the appearance of the initial and middle phases of bronchial filling in a patient suffering from chronic bronchitis. For this reason, not all the branches have the same calibre, and foliage is present in some regions while it is lacking in others. In these two figures we prove that the roentgenologic representation, in a frontal plane of branches that are directed in a sagittal plane, is confused and can be interpreted only by those who are accustomed to reading these roentgenograms (Fig. 19).

Lateral or Transverse Projection

Unquestionably, it is the transverse position that we can get a clearer and more distinct view of the mutual relations of the bronchial branches with the incisural planes and chest walls. In this position, the projection of the different segmentation branches of the bronchial tree makes their identification possible, and they may be observed along nearly the whole of their course.

Fig. 20 shows the upper, middle and lower lobe branches in the transverse position. This illustration represents the case of a patient

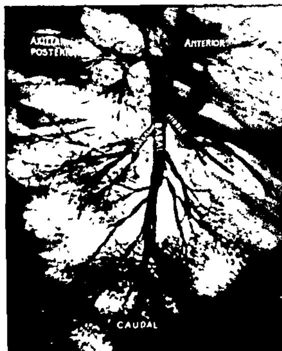


Fig 20 Lateral view of he bronchial tree of the pper lobe Arrow 1, an-erior branch, 2, axillary ranch, 3, posterior sub-ranch of the axillary ranch, 4, middle lobe runk, and 5, first dorsal ranch of the lower lobe



Fig 21 Roentgenogram in transverse position, where the middle lobe branches filled as far as the foliage is evident

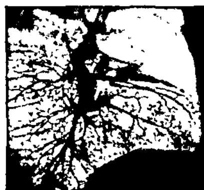


Fig 22 Roentgenogram in transverse position 1 and 2, first and second dorsal branches of the inferior lobe, 3, mediastinal branch, 4, first ventral of the inferior lobe, 5, middle lobe trunk

suffering from chronic asthma, which disfigures the conformation of the branches. The scarcity of fine branchings permits us to see the individualization of the branches even more clearly.

Figs. 21 and 22 also show the mutual relationship between the middle and lower lobe branches. The patient represented in Fig. 22 was suffering from a residual process after a lung abscess. The transverse position clearly illustrates the affected branch with its relationships.

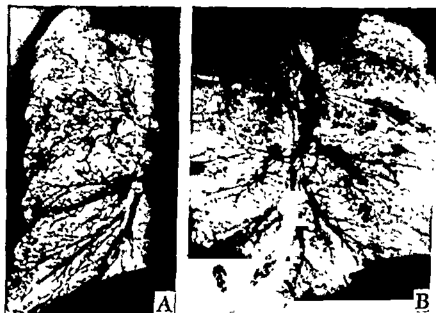


Fig. 23 Front position image (A) and transverse (B) in the same patient, transverse position is more illustrative than the frontal one. 1, superior lobe trunk, 2, middle lobe; 3, first dorsal, and 4, basal trunk

Left Lung—Frontal Projection

a) **Upper lobe.**—The bronchial branches of the superior lobe of the left lung are clearly shown in this projection. The two lobular trunks leave the left bronchus, in the following directions: the superior lobe bronchus goes upward and outward, and the lower lobe goes downward and outward.

The main trunk of the upper lobe immediately divides into two large bronchi; one seeks the lung base and corresponds to the *anterior*

descending branch (lingula lobe), and the other seeks the axillary region. Two sub-branches leave this trunk; one toward the lung apex, the *anterior ascending* or *apical*, and the other in the outer and anterior region, the *anterior axillary*.



Fig. 24 Initial phase of bronchial filling Arrow 1, superior lobe trunk, 2, inferior lobe trunk, 3, lingula lobe trunk 16 year old youth (Cont)



Fig. 25 Initial foliage phase in the same patient as in Fig 24 Here we may observe the relationship in frontal projection of the branches of both lobes Arrow 1, superior lobe trunk, 2, inferior lobe trunk, and 3 lingula lobe trunk

Fig. 24 presents the appearance of the upper lobe branches in the initial filling stage and in frontal position. The main trunks of both lobes, and the large and medium sized branches that shoot out from them, are clearly evident

Fig 25 (same patient) shows the appearance of chest at the initiation of the foliage phase of the bronchial filling.

b) **Inferior lobe.**—The roentgenologic projection of the branches corresponding to the lower lobe, if filling is complete, offers no difficulty in interpretation. If, on the other hand, the opaque medium has penetrated simultaneously into the branches of the upper lobe, and the images of the large air tubes have not been registered, confusion may result.

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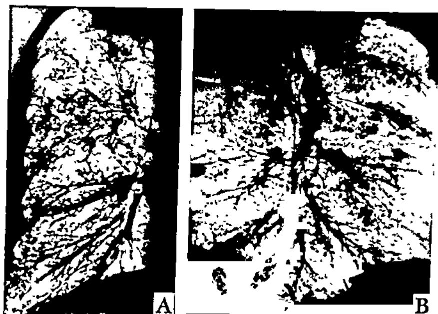


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Fig 24 Initial phase of bronchial filling Arrow 1, superior lobe trunk, 2, inferior lobe trunk, 3, lingula lobe trunk 16 year old youth (Cont)



Fig 25 Initial foliage phase in the same patient as in Fig 24 Here we may observe the relationship in frontal projection of the branches of both lobes Arrow 1, superior lobe trunk, 2, inferior lobe trunk, and 3, lingula lobe trunk

Fig 24 presents the appearance of the upper lobe branches in the initial filling stage and in frontal position. The main trunks of both lobes, and the large and medium sized branches that shoot out from them, are clearly evident.

Fig 25 (same patient) shows the appearance of chest at the initiation of the foliage phase of the bronchial filling.

b) **Inferior lobe.**—The roentgenologic projection of the branches corresponding to the lower lobe, if filling is complete, offers no difficulty in interpretation If, on the other hand, the opaque medium has *penetrated simultaneously into the branches of the upper lobe*, and the images of the large air tubes have not been registered, confusion may result.

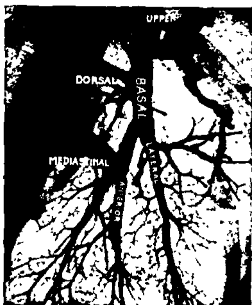


FIG 26 Bronchogram obtained during the initial phase of bronchial filling

The *ventral* sub-branches have a downward and outward course. The *dorsal branches go downward and inward;* their image covers that of the main trunk in *part of their course.*

In Figs. 26 and 27, we have indicated the ventral and dorsal branches of the lower lobe, taken in slightly oblique right anterior.

Transverse or Lateral Projection

As in the right lung, here also the transverse position radiogram shows more clearly the direction of the branches. Here also are branches which



FIG 27 Bronchogram obtained during the initial filling phase of both lobes Arrow 1, superior lobe trunk, 2, inferior lobe trunk; 3, basal trunk (inferior lobe), 4 and 5, ventral branches (inferior lobe), 6, trunk of the lingula lobe, 7, ascending branch, and 8, axillary branch

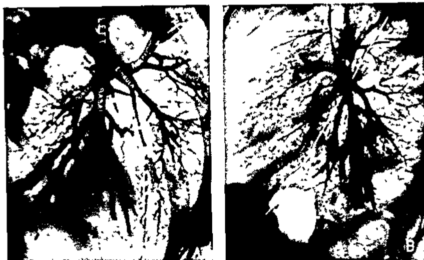


FIG 28 Radiograms in frontal position (A) in transverse position (B) the same patient (suffering from a lung abscess).

follow the course of the incisura, anteriorly as well as posteriorly.

The branches of the upper lobe project in the following manner: the *anterior descending* branch follows the incisural plane downward and forward; the *anterior ascending* upward and forward, and the *axillary* outward and backward, following the incisural plane in its retro-hilar portion.

The lower lobe branches project in the following manner: the first ventral branch, parallel to the incisural plane; and the other ventral branches, in a line almost parallel with the first, having a generally downward and forward direction.

The first dorsal branch has an almost horizontal direction backward, and one of the sub-branches travels upward and backward.

In Fig. 28 we present a frontal and transverse bronchogram of the same patient. The study of these images is more useful than a detailed description of the roentgenologic projection.

CHAPTER IV

Bronchographic Characteristics of the Normal Bronchus

The bronchi are not only air channels, they have anatomic and dynamic characteristics that enable them to fill a more important *function than that of simple* distribution tubes. These characteristics are not observed in the bronchial casts, nor are they found in the cadaver; many are not even evident in direct bronchoscopic examination.

Nor does a graphic image, obtained *after the filling of the bronchial* tree, help us to fully appreciate the functional role of the bronchus. Radioscopic examination should be made while introducing the opaque medium into the airways and a multiple serial graphic record obtained during inspiration and expiration. Only thus can we appreciate the complicated functions of the air tube so that we may formulate a theory of pathogenesis of the respiratory syndromes, based on physiologic changes. Of all methods of examination, contrast radiologic exploration and serial registration constitute the most complete procedures

The *anatomo-bronchographic* characteristics of the normal bronchus are indicated in:

1st) The calibre of the bronchus
2nd) The outline
3rd) The branching

The *broncho-physiologic* characteristics are shown by:

1st) The filling rhythm
2nd) The bronchial tone and the mechanism of the sphincter
3rd) The dynamism Respiratory variation in the calibre.
Peristaltic waves. Cough

1) **Normal calibre.**—We have no fixed method for showing calibre of the normal bronchus in the bronchogram, for various *technical factors* are involved, for example, focal distance, focal spot, distance of the bronchus from the film, etc. *Dynamism* (respiratory movement) tone, constitution of the *patient, area* affected, all cause

variations in bronchial calibre that make it impossible to give a definite measurement, as the anatomist does.

We must bear in mind that the calibre *is normal when the diameter of the bronchus decreases imperceptibly from its origin to its alveolar extremity*

These normal characteristics are typical of the large main bronchus as well as of the intra-lobular bronchi, and of the primitive branchings as well as the narrow bronchiole, for which reason, an area is filled with the opaque medium, the imperceptible reduction in calibre, undergone by all the branches from their base to their extremity, is evident.

2) **The outline** of the bronchus must be smooth or have slight undulations due to dynamism, for the wall of the bronchus possesses *peristalsis*. This undulation may be noted principally in the second and third order branches, that is, in those in which the muscular and elastic system predominate over the cartilage architecture At the root of the origin of the second order branches (lobular main bronchi sub-branches), *a strangulation* is usually seen as if a branch sphincter existed there. This strangulation is normal and does not appear in all the films if serial bronchograms are obtained thus confirming the opinion that the role of strangulation is narrowing or widening of the bronchial lumen.

3) **The fine secondary branching** should appear almost simultaneously in the whole of the lung area penetrated by the opaque medium, or in the order in which the medium has arrived at the main bronchus In general, the lower areas of the lung fields show the fine branching and foliage sooner, due to the fact that thoracoalveolar aspiration is stronger here, for it is associated with the great motility caused by diaphragmatic displacement. Moreover, these areas are ventilated by bronchi that run in an almost vertical direction, that is to say, they favor the descent of the opaque medium.

4) **Canalicular filling** must be *uniform*. The opaque column must not be interrupted, nor contain air bubbles or secretions. If these bubbles are few (one or two) and are transient, they should not be regarded as pathologic, for they are due to the fusion of multiple small air bubbles that leave the fine branches and form a large bubble that seeks the surface of the oil.

The *temperature* and *viscosity* of the opaque medium play a fundamental role, for the calibre of the secondary branching is very nar-

row; therefore the degree of viscosity of the liquid *influences the* speed of its progression. Cold *oils* having *a large opaque molecule* and *a high* degree of viscosity, penetrate with difficulty into the narrow *channels*. On the other hand, hot oils containing small opaque molecules have a much lower degree of viscosity *and go through the* fine bronchi rapidly.

Tests to establish a *normal time limit*, during which the opaque medium should reach the final branches, that is, to run the whole way from the main bronchus to the acini, serve no practical purpose. Due to various intervening factors, this time limit may vary without having any pathologic significance. The continued succession of the bronchial images, from the moment the opaque medium is introduced into the main bronchus until it penetrates the acini, is the best indication of normality. The time elapsing between these successive images has not the importance that has been attributed to it, for this period is conditioned by extra-bronchial factors (most of them technical).

The fundamental point to bear in mind is that *the bronchographic images are normally changing and transitory*. When this sequence of images is not produced in some branches, it is because of some intervening pathologic factor and the consequent disappearing or diminishing of the branch dynamism. In the following chapters, we shall show the difference in appearance between the bronchogram of a branch lacking dynamism and one normally possessing it.

5) **Normal foliage** is characterized by a fine *lace edging* that may be recognized with the naked eye, or better, with a magnifying glass, and after a variable period of time, but always a short one, this fine granulation becomes *thick* on account of its confluence.

The foliage should appear simultaneously in all the areas reached by the opaque medium at the same time, and should have no irregularities. The canalicular image is different from that of the acini, that is, the branching from the foliage, forms *transitory images*, while those of the acini are permanent. Once the foliage is formed it does not *disappear for several weeks or months, being more permanent in normal patients than in pathologic cases.*

Radiograms 29 A and B obtained in serial form, demonstrate the sequence of bronchial images, from the moment the opaque medium is introduced into the main bronchus until the foliage is formed.

Fig. 30 represents a normal lung, and in it we may appreciate

the characteristics of the normal bronchus. We may see very clearly the imperceptible decreasing of the bronchial calibre from the hilium to the alveolar end, the sequence of images, and the simultaneous appearance of the foliage in all those areas occupied by the opaque medium

In Fig. 31 filling is similar in the whole right lung, excepting in the apex where the progress of the iodized oil has been interrupted in



Fig 29A Initial filling phase Primary and secondary branches are observed (Cont)



Fig 29B The fine branches begin to fill (Cont)

the apical branch There is apparently no anatomical reason for this alteration in the direct radiogram and no other alterations in the image were seen excepting some abnormal figures, but the patient had been operated upon for a hydatid cyst situated in this apex and the dissection of anatomical elements had altered the physiologic state of this bronchopulmonary sector. These alterations were not visible in the direct radiogram but could be appreciated in this bronchographic serial record.

In all those cases in which aspiration dynamics are not complete due to an extra-thoracic or a thoracic cause, modifications in the filling rhythm due to a departure from mal-physiology are observed.

We have recognized these physiologic changes in a patient with

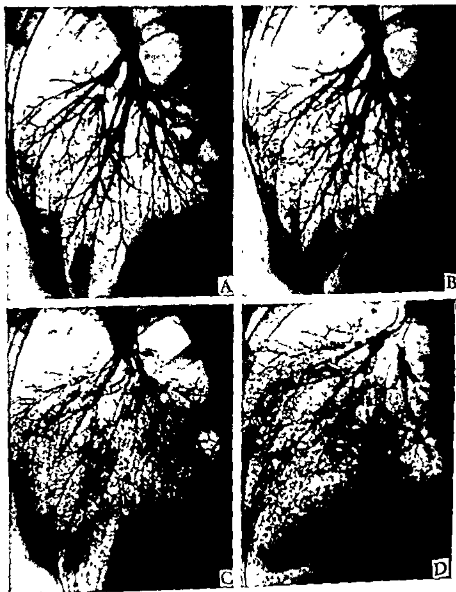


FIG 30 Successive phases of bronchial filling from the moment the fine branchings appear up to the appearance of the foliage.

pleurodynia who gasped on breathing due to pain. As shown in the serial radiograms in Fig. 32, the opaque medium has reached the middle and lower lobe of the main bronchus simultaneously, but, due to the lack of normal inspiration resulting from the descent of the

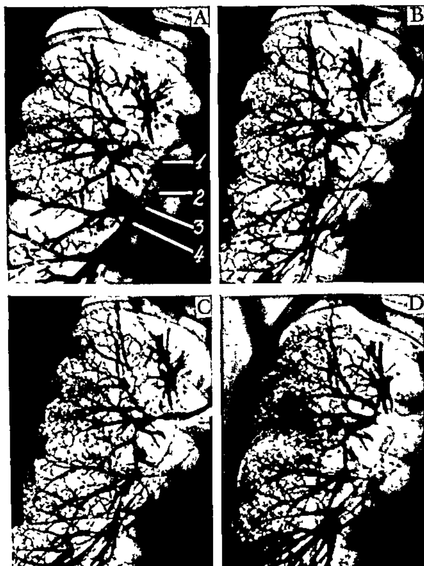


Fig. 31 A, B, C and D [illegible] record of the complete bronchial filling of the right lung [illegible]
hydatid cyst removed Roentgenographically only a residual tracing remains Dynamism, however, is far from normal









[illegible] ...dynia The [illegible] ...ior one, due [illegible] ...of the chest.

diaphragm, the iodized oil is drawn in more intensely by the middle lobe, for inspiration is of the superior chest type.

From this bronchographic picture we may get an idea of the effect of painful abdominal diseases upon the bronchopulmonary function.

Bronchial dynamism and tone have different functions and are of outstanding importance in bronchopulmonary pathologic processes.



Fig 33 Serial record of inspiration and expiration, intended to show the variations in calibre of the bronchi The bronchus has not been filled with the opaque medium because of its effect upon the walls. We have obtained only the image of the interior bronchial outline In the original there was a variation of 1 mm in the calibre of the bronchus between the end of inspiration and the end of expiration at the point indicated by an arrow

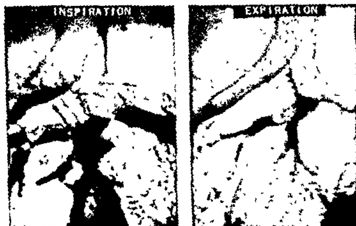


Fig 34 Serial record of the variation in calibre registered in the principal trunks of the bronchi

This dynamism is expressed by *variations in the calibre* of the bronchi, by *peristaltic waves*, and by the action of the branch *sphincters*.



Fig 35 Typical strangulations at the initiation of a bronchial branch due to the increased tone in the *trunk sphincter*.

The variations in calibre may be appreciated radioscopically during the introduction of the opaque medium into the air channel, by observing the expansion of the bronchus at the end of inspiration and its contraction at the end of expiration. This phenomenon has been recorded graphically by means of serial bronchograms (Figs. 33 and 34).

If the anesthesia has been deep, the bronchial calibre is increased, but if anesthesia is insufficient, the opaque medium becomes an intra-bronchial foreign body which intensifies the *tone* and *dynamism* of the wall.

The modification in the calibre is not entirely uniform. In the radioscopic view as well as in the serial radiographic record, we may see that all along the air channel, undulations are produced having a very slow rhythm but clearly differentiated in the serial radiograms. This *peristalsis* has been registered by various methods and studied carefully by A. Lusada and his collaborators [1]

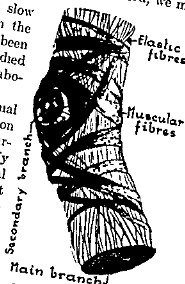


FIG 36 Disposition of the elastic and smooth muscle fibres around the starting point of a secondary branch (According to W S Miller)

This motility and tone of the bronchial branch are due to the power of contraction of the elastic and muscular fibres that surround the bronchus, they not only modify the calibre and outline of the bronchial branches of a second order, but also act as *sphincters* at the point where these branches originate

In bronchograms of patients with acute bronchitis, or of asthmatic patients, in which the tone of these fibres is raised, it is evident that at the base of the sub-lobular branches and in other smaller ones, strangulation of the bronchial lumen is produced, as if a *sphincter* surrounded the starting point of this branch. This trunk sphincter is scarcely visible, but in pathologic cases, especially in asthma, it is visible in many branches. In Fig 35 we present the bronchographic appearance of these bronchial branch strangulations.

The anatomical reason for this strangulation is the disposition of the elastic fibres and smooth muscle fibres in the bronchial branches that have their starting point in the main system Miller has sketched the disposition of the elastic and muscular fibres as shown in Fig. 36.

In this sketch it is evident that the elastic fibres (finely traced) are directed longitudinally parallel to the axis of the bronchus, and the muscular fibres (dark bands) form a network of bundles perpendicular to the elastic fibres, surrounding the bronchus like rings, and oblique

bundles that surround the starting point of the accessory bronchial branch.

The contraction of these muscular fibres strangulates this bronchial branching; *at the same time reducing the lumen of the main trunk.* In the bronchial casts obtained in the cadaver, this strangulation is very clearly evident, for a *post-mortem* retraction occurs in these smooth muscular and elastic fibres, causing *a reduction of the bronchial lumen* at the initiation point of the secondary branchings, as if the latter were joined to the main trunk by a pedicle.

The *nerve fibres* which control this dynamism come from the vagus and sympathetic nervous system. They form an *extra-chondral* plexus, a *sub-chondral* plexus, and a *sub-epithelial* plexus. The extrachondral plexus fibres are connected with those of the vascular sheath, and have their origin in the sympathetic nervous system. Those of the sub-chondral and epithelial plexus come from the lower branches of the vagus nerve and carry the nervous impulses received by the free terminations of the epithelium or motor impulses toward the muscular fibres.

Physiopathology of the Cough.—We shall now deal with the modi*fications of the bronchial calibre that occur during the act of cough*ing which, since this symptom accompanies nearly every bronchopulmonary process, induces us to think that its existence is attached to the ethiopathology of same. Radiographic records have permitted us to become acquainted with unsuspected aspects of the physiology of the cough, making us to judge it not as a simple act of expulsive hypertension, but as a *dynamic act of the mucous sheet which expulses the air or the secretions by means of a peristaltic wave originated in the fine bronchi and which ends in the vocal chords accompanied by an armonic movement of the functional sphincters.* It is something like what happens in the act of vomiting. *It is not the contraction of the* abdomen which expulses the gastric contents. It is an antiperistaltic wave of the stomach which begins next to the pilorus with its closing and ends next to the cardia with the opening of this sphincter. The abdominal hypertension favours vomiting, but does not cause it. In the bronchus it is not the air that expulses the secretions during the act of coughing; *the air itself is expulsed by the bronchus by a peristaltic expulsive wave as though it were a foreign body.*

Our observations effected on the various broncho-pulmonary processes and in different ages, have convinced us that the physiological

· *coughing* encloses an important dynamic function and that it not be interpreted solely as a reflex act determined by the irrita- of the bronchial tree, but as a mechanism of intelligent defense e broncho-pulmonary system

Fig 37, we show the aspect of the trachea and right bronchi ig inspiration. In the same figure we reproduce what was observed

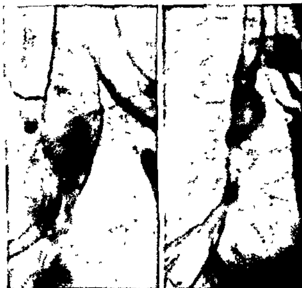


Fig 37 Trachea and main bronchi during inspiration and while coughing

in the same patient while coughing, keeping similar technical conditions to be able to compare truthfully. The comparative observations of both radiographical pictures allow us to appreciate the substantial changes occurred in the bronchi and trachea while coughing We see that the right main trunk has *plied* and *retracted* producing *undulations* At the root of the main bronchus in the medium lobe, an annular strangulation has been produced, as well as in the inferior lobe bronchus. The secondary branches have become filiform having diminished *up to a third of its normal calibre* But *the strangeness of* this is that all this dynamic act, so manifest, has taken place, *solely, in the bronchial tube, for the esophagic tube has not taken part in it.*



FIG 38A Comparative study of the bronchial tree, in the same patient, during inspiration and coughing



FIG 38B Comparative study of the bronchographic picture during inspiration and coughing in the same patient.

We have seen in many patients that the opaque product retained in the esophagus has not moved absolutely during the cough, proving that the expulsive act of coughing takes place *in the bronchial wall* and *not within the whole thorax*

In Figs 38A and 38B, we reproduce what occurs in the bronchial tree during inspiration and coughing in the same patient. In these pictures we can see the great variations of the calibre of the bronchus and the accentuation of the sphyncterian alternation which causes the

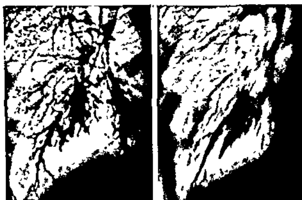


FIG 39 Effect of cough on the bronchial content, observed in a bronchiectasic patient It is only where no destructive zones of the bronchial wall exist that the content is expulsed

closing of the right upper bronchus and middle lobe. It is also important to state that it is just in these lobes where bronchiectasis exists.

We have stated that in the act of coughing, the bronchial wall contracts itself intensely in its sub-chondral part and that a contractive wave is produced which goes from the fine branching where it springs from, to the thick trunks.

It is an *active ejaculation of the bronchial wall* and not a simple thoracic-diaphragmatic hypertensive phenomenon which, by reducing the space, expulses the contents.

We have the proof of this fact by observing what happens during the coughing of the bronchiectasic We see that during this act, the ectasic portions which go together with the destruction of the active lining of the wall, *retain the opaque contents*, as seen in Fig 39.

These dynamic characteristics permit the differentiation of the reversible bronchiectasis susceptible of a medical treatment from those irreversibles which must be submitted to an early surgical treatment. Coughing permits the exact differentiation, for those ectasis that have destroyed the mucous sheet of the bronchus do not *expulse the opaque medium.*

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CHAPTER V

Radiologic Exploration of the Bronchus by the Contrast Method

Preparation of the Patient

A *preoperative* stage, in the real sense of the word, does not exist for carrying out contrast exploration of the bronchus. Nevertheless, it is convenient to limit the patient's food and liquids during the four hours preceding the examination, in order to reduce the hazard of vomiting.

Stimulants and sedatives are indicated only in exceptional cases. Formerly it was customary to administer them when the technique of exploration caused great discomfort, but this factor has now been eliminated. We have never used morphine or similar drugs before beginning bronchography.

Aspiration of the bronchus is very useful in cases of lung suppuration, when preparing for radiologic exploration. Nearly all suppurated lungs give insufficient bronchographic images, because the retained secretions constitute an obstacle to the penetration of the iodized oil into the cavities and bronchial expansions, but if drainage is carried out, together with bronchial lavage, this obstacle disappears and cavities that were not permeable when first examined now become permeable.

Anesthesia

There are many available anesthetics, their number increasing each year. For this reason we shall mention only the substance that so far has given us the best results.

This is "Bayer" Pantocain in 2% and 1% solution. The former is used for the supraglottic air channel and the latter for the infraglottic air channel.

The amount used depends upon the *age of the patient*, *debility*, and the *sensitivity* of the *bronchial mucosa*.

For *children*, a smaller quantity of anesthesia should be used than for adults, but this rule is difficult to keep, as their resistance is the

These dynamic characteristics permit the differentiation of the reversible bronchiectasis susceptible of a medical treatment from those irreversibles which must be submitted to an early surgical treatment. Coughing permits the exact differentiation, for those ectasis that have destroyed the mucous sheet of the bronchus do not expulse the opaque medium.

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2nd) A Vibilis or similar vaporizer
3rd) A gauze container
4th) A 3 cc. and a 20 cc syringe
5th) A Nelaton catheter, number 14 for children and number 17 for adults
6th) A pedal pail, a stool and a small table

Anesthesia is begun by vaporizing the nasal cavity on the side of the affected lung with a little Pantocain, twice into the nostrils is sufficient, once inside the nostrils three or four more shots will do.

After this initial step, a chronometer is set at fifteen minutes, the time necessary to produce anesthesia

After nose anesthesia we proceed with the mouth. First two or three injections in the fauces, making the patient open his mouth as wide as he can He is then asked not to expectorate After a minute he is asked to expectorate, and then to open his mouth, putting his tongue out as far as he can Then two or three puffs of the syringe are applied with the end close up to the uvula and tonsils. At this point the patient begins to resist If possible, he is induced to retain the anesthetic in his mouth for two minutes after which he again opens his mouth and puts out his tongue This time, however, it is necessary to *retract the tongue.* This is done with the left hand while the anesthetic container and syringe are firmly held in the right hand. Then the anesthetic is spread over the back wall of the pharynx and all the fauces Resistance is the rule at this stage If this step has been correctly carried out, a three minute wait ensues, if not, it must be repeated immediately

Nelaton's catheter is now inserted into the anesthetized nasal opening, and if anesthesia is complete, this should cause no trouble. A little practice in the introduction of the catheter is necessary as there is a tendency to push it upward instead of horizontally, which is the correct method.

The catheter should be introduced until, with mouth wide open, it appears behind the soft palate Once it is seen in this position it should be retracted 1 cm and fixed with adhesive tape over the nose or forehead, as shown in Fig. 40A.

The purpose of this catheter is to transport the iodized oil This arrangement permits all the necessary manoeuvers in the dark for introducing the oil during radioscopy and radiography, eliminating all the difficulties that may arise from the patient's position or radiologic

cause of a great loss of anesthetic from vomiting or from resistance. It is therefore necessary to make a distinction between the amount of anesthetic that *is introduced into the bronchial channel* and that *utilized. This should be well considered* before deciding to introduce the iodized oil into the air channel. If the doctor depends on the amount of anesthetic introduced as an indication that the patient is under anesthesia, he is likely to get a few surprises. In patients with suppurated lungs, anesthesia is difficult and requires greater doses. This may be because of the hypersensitivity of the bronchial mucosa, due to irritation from the continual passage of secretions, or because anesthesia does not act upon irritated mucosa, or because the secretions themselves dissolve the anesthetic, pick it up and throw it out. The fact is that cases of lung suppuration require two or three times the usual amount of anesthetic.

When the product has been well utilized, 5 cc. of Pantocain 1% is *sufficient to obtain perfect anesthesia in the child.*

In an adult, an excellent result is obtained with a few cc. more. It is necessary to add from 5 to 10 drops of a 1 per cent solution of Privine "Ciba" to the anesthetic *just before using it.*

The quantity of anesthetic in a 2% solution is also variable but *always small. This more concentrated solution is used, as we said* before, for the upper air channels: nose, fauces, pharynx, larynx and vocal cords.

The Technique of Anesthesia

For suppressing the cough reflex of the airways, the anesthetic may be introduced by several different techniques that we shall not consider here, as our purpose, as stated in the preface, is to relate our personal experience with bronchographic methods. *We shall, therefore,* discuss the methods that we employ and that we believe *to be the best.*

We use the two-stage method for producing anesthesia. The first stage consists of *anesthesia* of the *supraglottic regions,* and the second is the anesthesia of the *glottic and infra-glottic regions.*

Anesthesia of the supraglottic region includes anesthesia of the fauces, pharynx, larynx and vocal cords. To this end a 2% Pantocain solution is used in the following order: nose, fauces, pharynx and vocal cords. The following elements are necessary:

1st) A 2% and a 1% Pantocain solution

the bronchus of the diseased area. This is possible if the liquid has travelled freely through the trachea.

This procedure is fundamental, and care must be taken to effect it correctly; because if not, the anesthetic will go into the wrong bronchus and introduction of the iodized oil will cause defense reflexes that will make the exploration a failure.

The positions of the body are as follows:

1st) *Standing*, to explore both lung bases, right or left inclination according to which base is to be explored

2nd) *Standing*, but with a *forward and right inclination* to explore the middle lobe.

3rd) *Standing*, but with a *backward and right inclination*, to explore the posterior branches of the middle lobe (posterior apex)

4th) *Standing*, but with a marked *left inclination*, for the upper front lobe of the left lung in its inferior position

5th) *Standing*, but *backward and left inclination* to explore the lower part of the lower back lobe.

6th) *Incomplete dorsal decubitus, towards the right*, to explore the segments of the upper right lobe ventilated by the axillary and apical branches

7th) *Ventral decubitus and toward the right*, to explore the anterior branch of the upper lobe.

8th) *Ventral decubitus and with a left rotation*, to explore the apical segment of the left front upper lobe

9th) *Dorsal decubitis and left rotation*, to explore the upper segment of the left posterior lower lobe

For the apex exploration we use the lateral decubitus—right and left—in the manner shown in Fig 41. In this position we can obtain the exclusive filling of the superior lobe

All these positions have variations, often due to chest conformation (postoperative) or the need for special films, it will be necessary to resort to other positions that have not been mentioned. It is well to emphasize this because when the body is in the above mentioned positions, the anesthetic liquid will be sure to anesthetize the indicated regions in order to obtain images after the introduction of the iodized oil The individual case will decide the most advantageous positions of the body.

Anesthesia by Nebulization.—We practice anesthesia by nebulization with the apparatus invented by A. Remorino (Cordoba, Argentina) following his instructions This method has the advantage of producing sufficient anesthesia without the incon-

equipment itself. The anesthetic for the glottis and infraglottic zone is introduced through this same catheter. To introduce the anesthetic into the glottis an assistant holds the end of the catheter straight and the physician prepares a 3 cc. syringe containing 2 cc. of a 1% Pantocain solution. Then the patient is made to put out his tongue which is seized with a piece of gauze and retracted (Fig. 40B). The

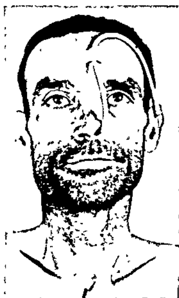


Fig 40A Catheter introduced into the nose up to the nasal fossa for the introduction of anesthetic and opaque substances



Fig 40B Technique for the infraglottic introduction of anesthesia or contrast medium.

anesthetic liquid is then slowly injected. This liquid falls almost directly on the glottis, as the epiglottis reflex has been depressed by the anesthetic and tongue traction also prevents its movements. When the anesthetic falls upon the glottis it produces a cough and if it has passed the vocal cords, a soft, temporary, croupy cough is heard during respiration.

After a one or two minute wait the manoeuver is repeated, with the body inclined so that the liquid may be distributed throughout

the bronchus of the diseased area This is possible if the liquid has travelled freely through the trachea.

This procedure is fundamental, and care must be taken to effect it correctly; because if not, the anesthetic will go into the wrong bronchus and introduction of the iodized oil will cause defense reflexes that will make the exploration a failure.

The positions of the body are as follows.

1st) *Standing*, to explore both lung bases, right or left inclination according to which base is to be explored

2nd) *Standing*, but with a *forward and right inclination* to explore the middle lobe.

3rd) *Standing*, but with a *backward and right inclination*, to explore the posterior branches of the middle lobe (posterior apex)

4th) *Standing*, but with a marked *left inclination*, for the upper front lobe of the left lung in its inferior position

5th) *Standing*, but *backward and left inclination* to explore the lower part of the lower back lobe

6th) *Incomplete dorsal decubitus*, *towards the right*, to explore the segments of the upper right lobe ventilated by the axillary and apical branches

7th) *Ventral decubitus and toward the right*, to explore the anterior branch of the upper lobe

8th) *Ventral decubitus and with a left rotation*, to explore the apical segment of the left front upper lobe.

9th) *Dorsal decubitus and left rotation*, to explore the upper segment of the left posterior lower lobe.

For the apex exploration we use the lateral decubitus—right and left—in the manner shown in Fig 41. In this position we can obtain the exclusive filling of the superior lobe.

All these positions have variations, often due to chest conformation (postoperative) or the need for special films, it will be necessary to resort to other positions that have not been mentioned. It is well to emphasize this because when the body is in the above mentioned positions, the anesthetic liquid will be sure to anesthetize the indicated regions in order to obtain images after the introduction of the iodized oil The individual case will decide the most advantageous positions of the body.

Anesthesia by Nebulization.—We practice anesthesia by nebulization with the apparatus invented by A Remorino (Cordoba, Argentina) following his instructions. This method has the advantage of producing sufficient anesthesia without the incon-



FIG 41 Position of the patient on the radiographic table and the seriograph

venience caused when utilizing the spray or topical substances particularly in timid patients and in children. The procedure is very simple and consists essentially in breathing the nebulized anesthetic particles contained in a pyrex glass balloon. The quantity of anesthetic usually is not over 2 cc. and the breathing time about 15 minutes. Fig. 42 shows a sketch of the apparatus and the method of using it.

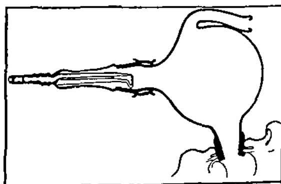


FIG 42 Apparatus for effecting anesthesia by nebulization

Hazards

Bronchial exploration may be accompanied by accidents due to *instruments*, *anesthesia* or the *contrast medium*, and these accidents may be *immediate* or *late*

We have not heard of any accidents due to the instruments used, as in the technique that we have just described no traumatic instruments are used (rigid or semi-rigid catheters, syringes with a metal tube, etc.)

A possible accident that must be borne in mind is *hemorrhage* This is not caused by wounds from instruments but is due to the intense effort of coughing. Even in patients who formerly had bloody sputum only periodically (we remember a case of lung abscess and one of lung agenesia) hemoptysis of varying gravity may occur This accident usually occurs during the final stages of the exploration, when the return of sensibility or the hypersensitiveness that follows anesthesia (vasodilation) causes strong cough reflexes The patient should be warned to restrain the cough reflex if possible

The introduction of substances into the bronchus may cause accidents of varying importance. Lung complications due to infection are of rare occurrence. Today, this danger is greatly reduced since less traumatizing techniques are used

The most frequent accidents are caused by *anesthesia* and the *contrast medium*.

The *anesthetic* can cause only two kinds of accidents *excitement* or *depression* The former occurs more commonly in young people, usually women, and it becomes apparent with varying quantities of the anesthetic substance The patient first manifests a disorientation. She becomes agitated, wants to walk and does so like a drunkard She will not listen to advice and refuses to be quiet. Her speech may be incoherent This period varies but usually does not last more than 5 or 10 minutes, and is followed by depression that may be accompanied by vomiting.

The anesthetic is not the only factor in this excitement for some patients have been explored several times and only sometimes become excited while at other times they remain normal Undoubtedly, there is a psychoneurotic factor involved.

These accidents diminish as less toxic anesthetics are employed, and skill in effecting anesthesia with a small quantity of anesthetic is acquired.

Accidents caused by the *contrast substance* nearly always occur.

The rare immediate accidents are associated with toxicity or tc the use of old or impure products. A careful choice of iodized oil, and precautions for keeping it in a good condition, should do away with these accidents.

Late accidents caused by the iodized oil are nearly all due to the absorption of the iodine, which is used almost exclusively nowadays in the contrast medium. Fever is one of the signs of intolerance. It may become manifest some hours after the exploration and continue during three or four days, but usually it does not rise very high. The onset of fever is nearly always accompanied by toxic manifestations, mucosa, *dermatosis, intestinal colic, nausea, lack of appetite* or *diarrhea.*

Fortunately, this symptomatic picture occurs infrequently, and the patients in whom these accidents occur have a hypersensitivity that may be anticipated. The knowledge of this sensitiveness does not contraindicate the exploration, but enables us to take special precautions to prevent the *swallowing* of the substance *during* bronchial exploration or afterwards when the patient begins to cough. In hypersensitive patients it would be wise to use a minimum quantity of the contrast substance, and to warn them of the postoperative possibilities of this exploration.

Post-Exploration Measures

Once the contrast exploration of the bronchus has been completed, certain precautionary measures are necessary.

Immediately after the exploration, the patient must be warned to make an effort to avoid coughing as far as possible. This will help to prevent hemorrhage in those patients who have a predisposition in this regard.

As an immediate precaution, the patient is advised not to take *foods* or *liquids* until *three hours* after the exploration, as the depression of the epiglottic reflex due to the anesthesia may cause the introduction of food into the airway.

In patients with a known sensitiveness to iodine, special postoperative care must be taken, especially the complete suppression of foods during 24 hours, allowing only the *ingestion* or *injection* of physiologic serum.

After the completion of the expiration, the patient may assume a position that will make the expulsion of the opaque substance easier.

This position should be the opposite of that adopted for the introduction of the substance He should be advised not to swallow, thus avoiding absorption of iodized oil.

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CHAPTER VI

Tomography of the Bronchus

The theoretical fundamentals of tomography and some of the results obtained in practice have prompted the radiologist to attempt to explore the bronchus without the use of contrast substances, using only the dissociation of the lung image that causes the displacement of the projection of opacities and transparencies during tomography.

The results so far obtained justify this method, and the number of explorations already done permit us to group the indications and evaluate the results. These attempts are amply justified by the fact that no contraindications to the method have been found, because no instrument or substance is introduced into the organism and the organism is not affected any more than when obtaining an ordinary radiogram.

Technique

Complicated apparatus is not necessary for tomography and any method that harmonizes the displacement of the tube with the radiographic film and allows for the modification of the speed of their displacement is sufficient to obtain clear tomograms.

The apparatus may be added to any modern radiologic equipment and various designs have been constructed by various radiologists using different electromechanic principles

In 1937[1] we devised a simple procedure for making tomograms with the patient in a standing position and also in decubitus. This apparatus consists mainly of a telescopic tube that, by means of a pincers at one end, takes up the x-ray tube and holds the film container or the Bucky-Potter diaphragm on the other end The rotating axis is situated in a metal angle having a groove and fastened to the edge of the radiography table. This rotating axis has a 20 cm. displacement.

Fig. 43 presents A, general view of the apparatus to be adapted

[1] S Di Rienzo and A Bohcr "El dia medico," Buenos Aires, 1937 "Roentgenpraxis," July, 1939, and Jan, 1940 "

to the radiologic equipment for obtaining tomograms; B, the same picture showing the pincers fixed to the tube frame; C, the end that is fixed to the Bucky-Potter diaphragm, this metal rod is responsible for giving the tube and the film the balancing movement that characterizes the tomography.

Fig. 44 is a diagram showing the adaptation of one end of the apparatus to the Bucky-Potter diaphragm; A, front view; B, side view.

Fig. 46 shows how the tube is displaced during tomography; positions a, b and c, show the extreme

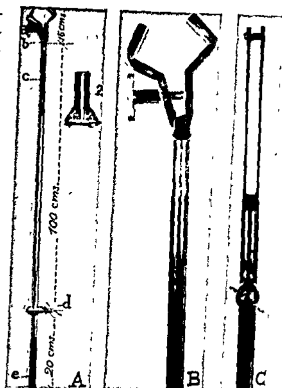


Fig 43 A, the apparatus for obtaining tomograms, seen as a whole; B, partial view of the end fixed to the tube, and C, a view of the end fixed to the Bucky-Potter diaphragm

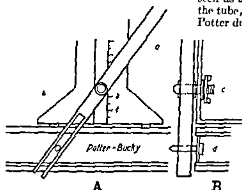


Fig 44 Schematic drawing showing the method of fixing the tomographic device to the Bucky-Potter diaphragm A, front view; B, side view; a, metal rod fixed to roentgen ray tube; b, metal angle with groove to fix the movable rotating axis; and d, metal piece that fixes the Bucky-Potter to the lower end of the device and compels it to follow its displacement

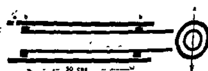


Fig. 45. Schematic section of telescopic tube, a, opening for the escape of air, b, friction rings

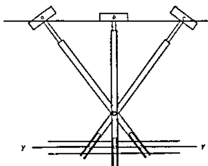


Fig 46 Drawing showing two extreme positions and the middle one in the movement effected by the radiogenic tube



Fig 47 A view of the device adapted to the table in standing position



Fig 48 View of the device adapted to the table in recumbent position

and middle positions of the tube, indicating how in all three positions the central ray has its incidence in the same place on the film and that the telescopic system of tubes allows for the displacement of the radiogenic tube parallel to the film These two advantages make it possible to obtain excellent results.

Figs. 47 and 48 indicate the adaptation of the apparatus to a radio-

graphic table which may be placed in various positions and has a Bucky-Potter diaphragm on the free end.

Indications

In recent years considerable disagreement has existed regarding indirect methods of bronchial examination, tomography as well as



FIG 49. Field suitable to direct exploration of a bronchus accessible to bronchoscopy, a similar field for tomography

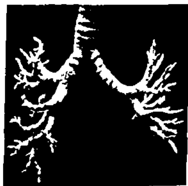


FIG 50 Scope of field for exploration of bronchial tree by means of bronchography.

bronchography; however, the usefulness of bronchoscopy has been recognized. The discussion has not yet resulted in any agreement as to the relative merits of these methods of examination, and in our opinion never will, as these methods of exploration complement each other and neither can be eliminated without affecting the results.

The field of bronchoscopy is more limited than that of bronchography. Bronchoscopy admits only examination of area that can be placed in a straight line with the exterior, and furthermore, only those bronchi that have a wider diameter than that of the bronchoscope. Bronchography, on the other hand, has none of these limitations. Figs. 49 and 50 clearly demonstrate the difference In Fig. 49 we see how far endoscopic vision reaches with possibilities of obtaining tissue for biopsy; Fig. 50 shows the branches that can be explored with the contrast method.

This comparison demonstrates clearly the greater scope of the contrast method, which in addition provides a graphic record of the

condition of the bronchus; the endoscopic on the other hand permits only a view of the bronchus.

The same thing is true in stomach exploration. Direct endoscopic methods, with or without a graphic record, have been unsuccessful in supplanting indirect radiologic methods, serving rather to emphasize the advantages and possibilities of the contrast method.

In examining the patient, direct radiograms should first be obtained by tomography, as this method does not effect the condition of the lung. Bronchography should be done later. If this order should be reversed, tomography would be unsuccessful as the remains of the opaque substance would cause confusing images.

Bronchoscopy and biopsy should be done last. This postponement of endoscopic examination is necessary, as the two previous methods may bring out diagnostic evidence that may make bronchoscopy unnecessary or they may show that the disease process is not within the scope of the endoscopic field. Furthermore, if a biopsy is done before bronchography a hemorrhage might occur and prevent the immediate carrying out of bronchography.

Tomography, bronchography, and bronchoscopy in the order named do not interfere with one another but rather complement the work of one another.

Tomography is especially indicated, as we have already said, in those cases where the disease is in the *trachea or in the first order bronchial branches; left or right primary bronchus and main lobe bronchi.*

In diseases in which *iodized oil as a contrast medium is contraindicated*, tomography may localize the pathologic process, and even provide the diagnosis.

When information as to the condition of the bronchus, beyond the obstruction is desired, tomography is superior to the contrast method.

In this case it is sometimes possible to utilize penetrating radiography, instead of tomography, providing the bronchi are surrounded by tissues of uniform opacity (atelectasis). If the bronchus is surrounded by tissues of varying opacity, penetrating radiography should not be utilized, as tomography isolates opaque areas, thus giving clearer image. Furthermore, it permits localization of deep disease processes.

Results

We shall not attempt to evaluate the results here. The discussion





FIG 52 Bronchogram of the same case showing that an obstruction is present but neither the size nor shape is as shown by tomography.

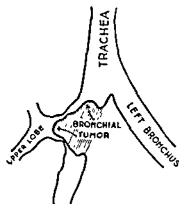


FIG 51 Tomogram demonstrating the presence of an endobronchial tumor indicated by the arrows and the schematic drawing below.

will be continued throughout the succeeding chapters. We shall consider at this point only special cases that demonstrate the possibilities of the method.

An interesting comparison between the results of tomography and those of the contrast method of exploration is provided in a case of bronchial carcinoma at the root of the right main bronchus directly in front of the origin of the superior lobe bronchus.

Fig. 51 is a tomogram that shows clearly the size and character-

istics of the tumor and the condition of the bronchus beyond the obstruction. The tumor is indicated by arrows. Bronchography, on the other hand, permitted us only to verify the presence of the tumor. As shown in Fig. 52, the iodized oil found the tumor and adjacent to it a passage connecting the main right bronchus with the bronchus of the upper lobe. In this case, *tomography* was evidently superior to *bronchography*, and even superior to *endoscopic examination* which permitted only a view of the upper part of the tumor

The following interesting case also demonstrates clearly the possibilities of tomography This patient presented complete opacity of the left chest and Koch bacilli were found in sputum. Everything pointed to a complete left atelectasis but etiology was not clear. Tomography in Fig 53 explains the cause of this atelectasis by bringing into evidence the location of the bronchial obstruction (arrow 1). The other arrows indicate the bronchial branches beyond the obstruction Endoscopic investigation showed that it was a case of ulcerovegetative tuberculosis which completely obstructed the opening of the main left bronchus

FIG 53 Tomogram showing the main left bronchus completely obstructed and the bronchial branches expanded at some distance beyond the obstruction Arrow 1 points to the obstructed bronchus and the other arrows to the expanded branches

Here also, tomography gave us more information than could have been obtained by contrast exploration, as this method as well as bronchoscopy would have been interrupted by the obstruction and we would have known nothing about the condition of the bronchus beyond the obstruction. Furthermore, bronchography is contraindicated in a case of active tuberculosis

Tomography gives excellent results when atelectasis or compression causes great displacement of the trachea or the main bronchi. In



Fig 54 Tomogram of a case of thoracic retraction where the trachea and right main trunk deformity are evident

these instances we must not be content with obtaining middle planes, but we must look for revealing images more distant or closer planes and even in oblique or transverse positions. A previous radioscopic examination is a helpful guide to the best position to be adopted by the patient. Fig. 54 shows us the result of one of the explorations in a case of an old pleuropulmonary process. The upper lobe atelectasis has retracted the trachea and its bifurcation, grossly deforming the bronchial architecture of this region.

A comparative study of the results of direct radiography, tomography and bronchography favors tomography, as it proves the many possibilities of this



Fig 55 Direct radiogram, tomogram and bronchogram demonstrating possibilities of each method in the case of a residual cavity due to the surgical removal of an hydatid cyst

procedure in selected cases and in skillful hands.

Fig. 55 illustrates the results of one of the investigations in a patient who had a residual cavity following an operation for hydatid cyst. In the first of the three panels, we see the direct radiogram; the arrow is pointing to a small lozenge-shaped ulcer in the apex having sclerotic walls. The center panel represents a tomogram (front plane) in which transparency and fibrous traces that continue up to the lateral wall are more evident In the third panel, a bronchogram



Fig 56 (left) Tomogram showing the bronchial division of the left main trunk and the communication of the cyst with the ascending forward bronchus (Cont in Fig 57)

Fig 57 (right) Bronchogram showing the position of the bronchial branches as compared with the tomographic image

reveals the cavity, thus confirming the findings from direct radiography and tomography.

Figs. 56 and 57 illustrate another case which allows a comparison of tomography and bronchography, revealing the ample possibilities of tomography when it is applied to the study of the large air trunks. This patient had an upper lobe hydatid cyst ruptured into the ascending front branch. Fig. 56 illustrates how tomography reveals the main left branch and the division of the two main branches for the upper and lower lobes The upper lobe trunk gives out two branches at its origin, one toward the cyst and communicating with it, and

another passing beneath the cyst, and displaced by it toward th
middle and corresponding to the lingular trunk.

In Fig. 57 we have the result of bronchography, including th
views of the main trunk and the immediate branches obtained b
tomography.

CHAPTER VII

Serial Exploration of the Bronchus

Anyone who has had the opportunity of controlling radioscopically the introduction of an opaque substance, such as iodized oil, into the bronchial tree, must have wondered at the changing images and the schematic disappearance at the bronchial filling at first, until after a few seconds, branches fill and foliage is formed. Another point of interest is the difference between the image of bronchial dynamism obtained by means of radiograms. This difference also existed some years ago between the radioscopic and radiographic examination of the digestive tube, especially in the duodenum. The result was that lesions plainly visible by radioscopy were only accidentally registered on the film, but improvement in technique overcame the difficulties, so that it became possible to note the serial registration of the basic images on the fluoroscopic screen, and by means of compression and special measures, the images of the organ being examined can be registered at the right moment.

It seems logical that we should utilize these devices for the exploration of the bronchial tree, when the radiologic picture of the pathology is one of changing images. Examination of the airways, however, presents greater difficulties than those found on examining the digestive tract. The digestive tract can be submitted to compression for the most part, and the formation of the images can be accelerated or retarded. This is not possible in the airways.

In the digestive tract, the opaque substance travels in opposition to the laws of gravity, while in the respiratory system, iodized oil follows this law. The digestive tract is a single channel and the superposition of two segments can easily be avoided by means of compression and other means whereas the respiratory tract has an infinite number of branches and there is no way to avoid the superposition of images. To make things even more complicated, the air tube is enclosed in a semi-rigid box with walls that are partially opaque to x-rays.

The examination of the digestive tract may be repeated daily, as the opaque substance is retained for only a few hours while the

examination of the air tube cannot be repeated immediately, as the opaque substance is partially retained in the acini, remaining there persistently for months and seriously impeding the interpretation of the new images.

The digestive tract is subject to its own involuntary dynamism, peristalsis, and also a voluntary action, namely, respiration. Respiration can be suppressed by will power and the effects of peristalsis *can be neutralized, as it is a slow movement that registers images in* fractions of a second. For this reason no great difficulty is experienced in the obtaining of clear radiograms of the digestive tract.

The respiratory tract, on the other hand, is subject to intense dynamism, as breathing takes place in the explored organ itself; furthermore the iodized oil gives rise to an involuntary defense action that stimulates this dynamism. We can neutralize all this by asking *the patient to hold his breath for a moment, and we can depress the* cough reflex by anesthesia. But we still have adjacent to the bronchial tree, another organ—the heart—submitted to an intense and rapid movement, that transmits pulsations to the neighbouring organs at the rate of more than one per second. This rhythm *is increased during* radiologic examination with iodized oil, due to the exciting effect of the anesthetic, the emotional state of the patient and the central stimulus caused by diminished hematosis, due to the displacement of air by the opaque substance.

All these difficulties have retarded the serial examination of the bronchial tree and caused the first attempts to fail.

Technique

Serial exploration of the bronchus requires a strict *technique* if it is to be carried out successfully. It does not consist solely in obtaining numerous films showing opaque bronchi, just as a serial exploration of the digestive system does not mean merely obtaining a series of radiograms. It is not the mechanical act that should define a method, *nor is it the number of films that* determine its value, but the intelligent work of the physician in registering the successive phases of the same phenomenon or the variable images determined by the dynamism of this organ. *A pile of serial films has no medical* value, if the technician was not completely absorbed in his diagnostic problem.

Serial bronchography requires special *instruments* and *skilled assistants.*

The necessary *instruments* are the following:

1st) *An electric generator with a revolving anode and the best focus possible*
2nd) *Albrecht's seriograph* or a similar one. The common plate-shifters or other seriograms lacking a movable Bucky-Potter diaphragm are inefficient and should be discarded.
3rd) At least *three plate holders measuring 24 by 30 cm* and two measuring 18 by 24 cm with their corresponding reinforcement screens *exactly* the same. Different type reinforcement screens will cause unequal exposures and make the exploration a failure.
4th) Five *assistants*

The first introduces the iodized oil, the second takes his place at the instrument board and sets the exposure time for frontal, oblique and transverse radiograms, the third assistant should place and remove the plate holders as the radiograms are taken, and hand them to the person who is to take them to the nearby developing room. In the dark room, the fourth assistant, a photographer, removes the exposed film and places a new one in the plate holder. The films are not developed until the exploration is completed.

In addition to this team, there is the radiologist, who, before the fluoroscopic screen, must decide the precise moment for taking the radiogram and the appropriate positions, and who does this work himself.

In serial bronchography, the following system should be followed. The anesthesia is not different from that used for a simple exploration, and up to the moment for introducing the opaque medium, the preparation of the patient is the same. He should be placed on the operating table in the best position for filling the bronchi of the region to be explored. In this position a radiogram is obtained in the seriograph, the values to be used are those thought most useful for bronchography. It is then necessary to wait for the opinion of the assistant photographer, as to whether the exposure has been correct. Meanwhile the bronchus to be explored has been anesthetized, using the choice position. Ten minutes later, the opinion of the photographer should be known, and accordingly, we shall continue with those values or modify them according to the opinion of the photographer. We must emphasize that this procedure is necessary. nprovising leads to surprises, and surprises to failures. With this eparatory procedure, serial bronchography is begun (Fig 38).
When each assistant is at his station and the patient in correct tion, the doctor orders the slow introduction of the iodized oil, e he, himself, observes on the fluoroscopic screen the prog

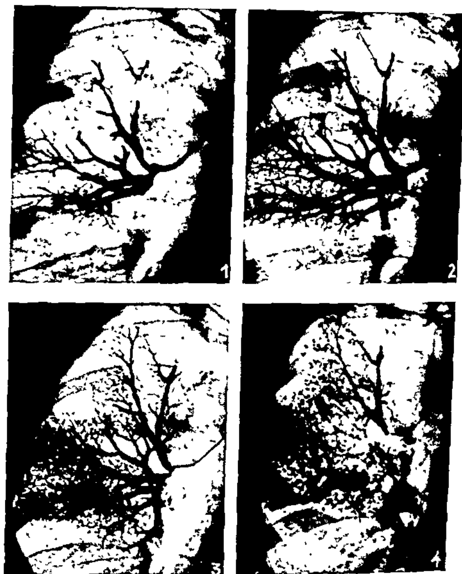


Fig 58 Serial exploration of right upper lobe only.

the medium. When the iodized oil reaches the bronchus of the affected zone, and before images of total filling are formed, the doctor orders the patient to stop breathing and obtains a film that registers the early image of filling. From that moment the films follow in quick succession and the patient is moved a little in one or another direction

in order to obtain the stages that the radiologist may think suitable. The technician should obey promptly the doctor's commands of "Front," "transverse," "oblique."

Having completed the main part of the procedure, and having introduced all the iodized oil, the doctor examines the whole bronchial image and takes a radiogram if he thinks fit. After a few minutes the lung image shows the late half empty bronchus, and at the same time, the more complete filling of the alveoli. At this moment, images of the interior outline may again appear just as they looked when the introduction of the opaque substance was begun

The number of radiograms that should be obtained in this serial exploration cannot be anticipated. If the doctor is able to obtain the radiograms at the exact moment when the patient is quiet and has held his breath, there will be no doubt as to their clearness. If the reverse is true, it will be necessary to obtain a great many films, as many of them will be of no use due to the respiratory movements of the patient.

Indications

When difficulty in diagnosis is anticipated on account of bronchial symptomatology presented by the intrathoracic picture, a serial exploration is necessary.

When an incipient *lung cancer* is suspected, although there are no manifestations of bronchial obstructions, it is necessary to explore the bronchial tree by the serial method, as only by this technique can we differentiate between the small endobronchial proliferations or initial stenosis and the transparent images due to gas bubbles, drops of pus or insufficient content of iodized oil

When we wish to estimate and register the *dynamism* of a lung rea, or the *rhythm of its filling*, serial exploration is indicated as the nly means of ascertaining the symptomatology and showing in aphic form the aspects of altered bronchopulmonary dynamics

In serial exploration the *canalicular* image can be clearly distinshed from the *acinus* image of the bronchial system, as the images registered consecutively. For this reason, this method should be l whenever it is necessary to record the conformation and position ie bronchial branches, their dislocation, etc. We should always repared to carry out a bronchography in serial form, as the ition may arise during exploration.

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CHAPTER VIII

Bronchopulmonary Malformations

Bronchopulmonary malformations are seen in clinic with unsuspected frequency and in varied forms The frequency and polymorphism of their clinical and radiologic features makes it necessary to differentiate them from all obscure bronchopulmonary diseases

These malformations may be grouped as follows·

1) *Congenital malformations* that during gestation have affected the bronchopulmonary system to such an extent that extrauterine life is impossible. Those individuals so affected are never considered patients as they have neither a history nor a radiologic record For this group we have only autopsy data

2). Bronchopulmonary congenital malformations that made extrauterine life impossible and affect the life of the patient according to their degree of seriousness. Some of these individuals die from their first infectious disease, they, therefore, have no radiologic records Others get over their first diseases, and reach adolescence with a history of repeated bronchitis, asthma, pneumonia, lung congestion, etc.

3) The third group is constituted by those malformations that affect the normal bronchopulmonary structure, but there is no history of anatomic changes unless other processes intervene to bring them to light. These persons have normal infancy and attain normal adolescence Frequently then we find unsuspected lesions on radiologic examination of the lungs, and they may be trivial or may be due to a disease process. In the latter case it is not always easy to verify the congenital character of the disease, and it is then that we must remember that only the first group mentioned are true bronchopulmonary malformations since there have been no intervening dynamic, infectious or biologic factors in the development of the individual, to give the disease both a congenital and acquired character.

Regarding this vast problem of malformations, we shall consider only their radiologic aspect and attempt to explain their pathogenesis and the anatomical basis of each type.

Embryology

Alterations in embryologic development lead to the various malformations we find on autopsy or in clinic.

The bronchial tree may stop growing the *moment the primitive* bud of the lung segment appears; that is, when the formation of the main bronchial tube begins. This happens *between the first and second* months of intrauterine life. We then find complete absence of one lung and its place is occupied *by connective tissue. This malformation is* called *pulmonary agenesia* and may imply the absence of one or both *lungs or lung lobes.*

Growth may stop later on, when the secondary branches originate. *At this stage, the bronchial bud that has been included due to* unknown causes, bulges, forming a great cystic cavity containing a great or a small amount of liquid.

The cystic wall usually has the *anatomical structure of a medium* calibre bronchial tube. This shows that it has developed at the moment of intrauterine life when the mesenchymal elements of the air tube appear (cartilage, elastic, and muscle fibres).

This malformation that occurs between the third and fifth months is called an *air cyst.*

The cyst may be single or multiple. Exceptionally it is found alone; the usual thing is to find adjacent to the air cyst a scarcity of or poor secondary branching and alveolication. This permits a differential radiologic diagnosis among other images that are similar in direct radiography, but in which bronchography does not evidence alterations in the number or development of the branches.

If the bronchial tree continues its normal evolution up to the fifth month, but stops its growth the moment the fine branching of third, fourth, or terminal order begins, we have the malformation called *alveolar agenesia.* The lung corresponding to the affected zone may be able to breathe as it has almost completed the second stage of its growth, during which, even though there are no alveoli, hematosis may be possible through the fine air tubes and the abundant capillary vessels that surround them. Due to various factors, this picture is modified in the adult, especially on account of post-natal development of the lung, pulmonary dynamics and the added effects of infections.

If the bronchial tree has grown normally up to the seventh month of intrauterine life, but stops growing then and instead of forming the

acini, bulges into a cyst, we then have what we call *cystic or sacciform bronchiectasis or bronchial diverticulosis.* These little sacs that have the appearance of *insufflated acini* anatomically form *expanded bronchi* as they have their anatomical structure.

As has been said, the malformations found in adults are never pure, as the intervention of dynamic phenomena in respiration and the effects of infection cause a modification of the congenital picture This modification stands out especially in all those genesias of the ampullar

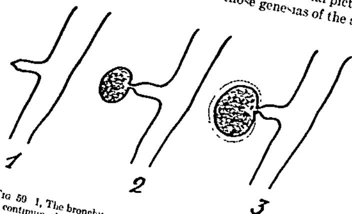


Fig 59 1, The bronchus partially obstructed due to a defect in growth but continuing beyond the obstruction 2, The terminal portion of the bronchus continues growing but expands on account of retained glandular secretion 3, After birth, respiration makes the ampullar expansion of the cyst even wider, due to the valvular effect of the bronchial obstruction

cystic type in which the following seems to happen (King J and Harris L.C.)[1]

The congenital malformation appears at the time of birth as a little bubble or cyst situated at the end of the bronchial branch abnormally developed This cyst communicates with the bronchiole y means of a narrow tube through which the glandular secretions re expelled with difficulty. This retention has already caused the pansion of the cyst in pre-natal life (Fig 59).

After birth, the air may enter this cyst with the expansion of the nchus during inspiration, but due to the valvular closing of the nchus which communicates with the cyst, expiration of this air is

[1] ...genital Lung Cyst—"J A M A," 108, 274, 1937

difficult thus increasing tension in the cyst and contributing to its expansion.

These last malformations may combine and present a predominate cystic or bronchiectasic aspect. For this reason they have been given a variety of names, such as: *polycystic lung* (Bellucci), *Cystiform lung* (Vacarezza), *agenetic bronchiectasis, cystic bronchiectasis,* etc.

Roentgenographic Aspects

The radiologic aspect of bronchopulmonary malformations is



[illegible] The lung [illegible]



FIG 60B Case of cystic bronchiectasis The branches end in sacciform expansions There is a scarcity of foliage and emphysema. The polycyclic aspect of the parenchyma may be seen over the area filled with the opaque substance

varied. Some scarcely disfigure the lung image while others fundamentally change the aspect of the lung. (Fig. 60, 61, 62).

A direct *radiogram* of the lung may disclose a malformation, but bronchography gives the best radiologic picture of the bronchial tree by the use of the contrast medium. This method should be employed when it is desirable to verify the presence and extent of the malformation.

We should mention *tomography* as an auxiliary procedure as it gives us a valuable picture of the actual state of the lesions in the lung.

Lung Agenesia

Hemithorax lung agenesia (the only type in which life is possible), has a radiologic image similar to that of atelectasis.



FIG 61 This is an *alveolar agenesia* There are no fine branches, and the only others present are thick and end in a glove finger There is no foliage

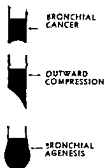


FIG 62 Various types of interruption of the contrast medium The essential characteristic of the stop, due to agenesia of the bronchus, is the terminal expansion of the bronchial lumen

In some of the exceptional cases reported—25 cases in world literature, although the list has not been revised—there was a uniform opacity that did not present any radiology characteristic to differentiate it from atelectasis. It was necessary to resort to contrast bronchography which revealed that the main trunk of one side of the chest, or a whole lobe, ended in an expansion or sac (Fig 62). It is precisely the formation of this sac that allows us to differentiate between bronchial closing and an obstruction due to a tumor.

Complete absence of lung tissue may occur in only one lobe; and in this case direct radiogram and bronchograms show the same signs of agenesia that appear in agenesis of the whole lung. We have no statistics regarding malformations.

There exists the possibility of mistaking the rupture of the main bronchus with a bronchial agenesia, especially when the rupture of the bronchus is observed many years after it has occurred.

Fig. 63 shows a bronchography and a direct radiography of a patient who had suffered the rupture of the main right bronchus due to a severe external contusion without any lesion on the thoracic wall. The bronchography shows a "glove-finger" stop as the agenesia of the lung originates it.

It was only bronchoscopy that permitted the observation of the scar and thus find the relation between the patient's history and his actual disease



Fig 63 Direct radiography and bronchography in a case of rupture of the right main bronchus

Air Cyst

The picture of the *air cyst* by direct radiography presents various aspects, depending on its actual state and that of the accompanying malformations.

It is well known that these cysts may contain a *great or a small* amount of fluid and that infections may have modified their radiologic picture and symptomatology. In direct radiography, the cyst has the

characteristics of a cavity with a fluid retention A well defined outline is prominent in the conformation of this image of a pseudocavity and this same characteristic is also usually found in the residual cavities of the lung hydatid cyst and the large suppurated emphysema cysts.

In certain cases radioscopy of air cysts demonstrates an unmistakable characteristic, namely, *expansion during inspiration and retraction during expiration*. This phenomenon is sometimes so pronounced that during expiration the cavity image may even disappear. These modifications do not occur in images of a residual hydatid cysts cavity or an emphysema vesicle

At other times, the air cyst may appear without retention fluid and it then shows an image resembling a ring with a smooth outline Some air cysts have a fluid content sometimes and are dry at other times. Then the images alternate

We find other radiologic signs *in the neighborhood* of the cysts Inside the large cyst we may find panels that appear as lines crossing the ring image of the cyst The neighbouring lung parenchyma only occasionally shows a normal aspect It is usual to find other small annular or an absence of the normal tracings of the lung reticulum. The ring images belong to other cystic formations or bronchiectasis surrounding the large cyst. The absence of normal tissue is due to areas of emphysema or partial alveolar agenesis.

However, the most characteristic image of an air cyst is obtained not by direct radiography but by bronchography The injection of iodized oil provides definite data regarding the origin of the cavitary image. Iodized oil penetrates a non-suppurated air cyst with difficulty because the bronchial branch communicates with the cyst by a very small opening If the cyst has ruptured, this communication is larger and may then give rise to confusion, but neighbouring images aid in making a definite diagnosis. These images obtained with iodized oil are as follows. the bronchial tree with few secondary branchings and scant foliage, but a cylindrical and sacciform expansion The sum of all these radiologic indications confirm the presence of the air cyst

Tomography reveals emphysema and bronchiectasis in the neighborhood of the air cyst as well as the characteristics of the interior of the cyst (trabeculae).

Case 1. This patient was admitted to the Rawson Hospital by Dr. Raul

Ortiz on account of a lung condition The family history of the patient is of no importance; and the personal history is as follows: He had measles at two or three years of age and pneumonia at the age of 14 After that he was *always in ill health Eight months after his recovery from pneumonia, during* one of his frequent coughing fits that remained as a sequel, he vomited pus The actual disease began in 1934 when the bronchitis became *acute* with a *bloody* expectoration, although Koch bacilli were not found in the sputum



Fig 64 Direct radiogram showing a cavity in the middle field of the right lung (Cont)



Fig 65 Tomogram of the same case, revealing an irregular and interrupted outline, as well as the presence of other annular images. (Cont)

He suffered from intense weakness, insomnia and loss of appetite, but there *was no rise of temperature* He recovered almost spontaneously but a year later he suddenly got worse due to sudden and severe hemorrhage. With rest and medical treatment he recovered but *hemoptysis* returned with

days and the patient recovered. Nevertheless the bloody expectoration continued, and in July 1939 he was admitted to Rawson Hospital on the service of Dr. Raul Ortiz.

The physical examination ...

ties of 50 c c. per day. Sputum was sometimes purulent and at other times contained blood but no Koch bacilli. Pulse 78 and blood pressure 130/90 Weight 54,000 Kilos, height, 1.50 metres Weimberg Ghedini, and Gassoni

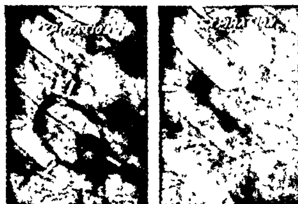


Fig 66 Radiograms taken in transverse position

position, but less clearly shown (Fig 67)

All these radiologic records revealed characteristics that are not common in lung diseases and led us to suspect that we were dealing with an obscure condition

Bronchography cleared up the diagnosis, as may be seen in Figs. 68, 69 and 70 In Fig 68 the image of the bronchial tree in frontal position shows the disappearance of the normal foliage and the presence of a large cavity

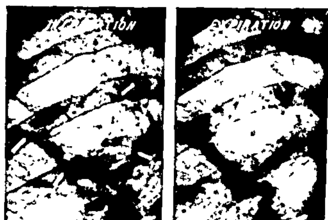


FIG 67 Radiograms taken in frontal position (Cont)



FIG 68. This bronchogram reveals the extensive alterations in the bronchial tree and ampullar and cystic expansions. There is a scarcity of secondary branches and foliage (Cont)



FIG. 69 Bronchogram obtained a few seconds after the previous one, showing the cystic cavity containing more contrast substance (Cont)

incompletely filled, as well as multiple small cavities The iodized oil has penetrated with difficulty into the large cyst and with great ease into the small ones Fig 69 shows the bronchial aspect one minute later, the cyst is now more completely filled, and the small terminal cavities of the bronchi are filled completely with the iodized oil

The scarcity of branches is evident as well as the absence of foliage The greater bronchial branches have an irregular calibre, and their filling is moniliform in character denoting the absence of pus.

The radiogram in Fig 70 is a view of the same lung seen in the oblique position, and reveals the relationship of the large cyst to the neighbouring bronchi and the terminal bronchial expansions

The patient remained in the ward several months and during that time repeated diagnostic tests for bacilli were negative

In a case of this nature only one diagnosis is possible, namely, congenital malformation of the lung Within this diagnosis, the case would correspond to a case of *complicated or suppurated cyst* Simultaneously there exist other multiple small cystic malformations, that affect the bronchial tree in the vicinity of the large cyst The co-existence of these processes confirm the diagnosis of cyst



Fig 70 An oblique view in the same case showing the relation between the cystic cavity and the other bronchial changes (End)

Case 2. This case is similar to Case 1 The patient, a boy 8 years old, had whooping-cough at the age of five and at the age of 6 developed a lung condition with fever, which was diagnosed as *pneumonia complicated by pleurisy*. One night, he vomited and the vomitus contained pus The cough continued and was accompanied by expectoration Three months later the boy had measles. At the time of admission he had no fever and was in good general health The Ghedini and Cassoni reactions were negative No Koch bacilli were found in the sputum

Direct radiography (Fig 71), showed a peculiar picture at the base of the left lung. *The costodiaphragmatic sinus was obstructed, and the pericardiac region showed an ovoid ring-like image, having a clear superior outline but the inferior outline merged into the shadow of the costodiaphragmatic sinus.*

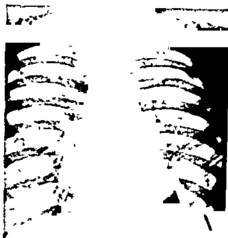


Fig 71 Frontal image showing an annular shadow in the left base and a costo-diaphragmatic shadow on the same side (Cont)



Fig. 72. Shadow in transverse position. A polycyclic annular shadow with an opacity in the lower portion and a visible level. (Cont)

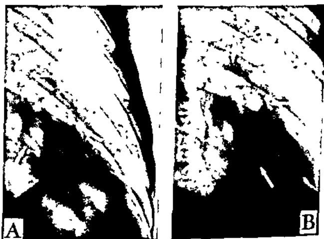


Fig 73 Serial radiogram taken during expiration (A) and during inspiration (B) The change in the size of the image is evident. (Cont.)

... he ring-like ...

h ... piration and its contraction during expira-



Fig 74 Bronchographic view of the previous case A cavity has partially filled, there is sparse secondary branching and lack of foliage in the area adjacent to the cavity (Cont)



Fig 75 The same case in dorsal decubitus, showing the irregular shape of the cavity In E. L. the injected contrast medium may be seen

tion In Fig 73 we have a record of these two views obtained successively by means of serial radiography at the same focal distance.

The bronchographic study showed clearly the existence of a communication between this expanding and contracting cavity and the bronchial system; but of greater importance is the fact that in the vicinity of the cavity there was revealed a profound disorganization of the branching system, both as to the number of branches and their anatomic characteristics The scarcity of fine branching was evident as well as the lack of foliage and the expansion of the existing secondary branches

These characteristics, together with the absence of clinical signs and

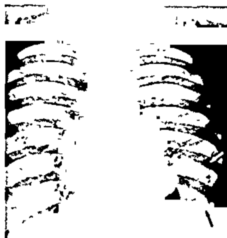


Fig 71 Frontal image showing an annular shadow in the left base and a costo-diaphragmatic shadow on the same side (Cont)



Fig 72 Shadow in transverse position. A polycyclic annular shadow with an opacity in the lower portion and a visible level. (Cont)





Fig 73 Serial radiogram taken during expiration (A) and during inspiration (B) The change in the size of the image is evident (Cont)

In the transverse radiogram, the polycystic appearance of the ring-like

like polycyclic image during inspiration and its contraction during expira-



FIG 74 Bronchographic view of the previous case A cavity has partially filled, there is sparse secondary branching and lack of foliage in the area adjacent to the cavity (Cont)



FIG 75 The same case in dorsal decubitus, showing the irregular shape of the cavity In E E the injected contrast medium may be seen

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These characteristics, together with the absence of clinical signs and

symptoms led us to the diagnosis of a congenital malformation of the air cyst type, not a suppurating process (Figs. 74 and 75).

Case 3. This patient 40 years of age was admitted to the surgical clinic for treatment of a subacute lung abscess. His illness had begun about two months previously, with an acute lung process characterized by a sudden rise of temperature with lancinating pain in the base of the right chest and a cough that at the beginning was dry but later was accompanied

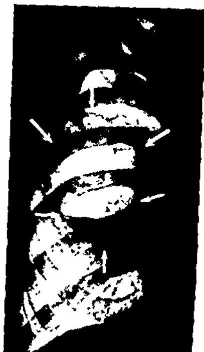


FIG 76 Direct radiogram showing a cavity in the middle field of the right lung (Cont)



FIG 77. Radiogram taken at the end of medical treatment The cavity lacks clean cut outlines (Cont)

by a salmon-colored expectoration. After four days the fever dropped gradually and remained between 37 5C and 38°C. Nearly a month later the expectoration, that had diminished, became more intense, especially when sitting up in bed in the morning. Later the patient had two slight hemor-

tion, the only abnormality was the finding, in the right subescapular region,

of an auscultatory murmur and a rhonchus. Laboratory examinations did not reveal the presence of Koch bacilli, nor did they lead to the diagnosis of any specific disease. The radiogram, however, revealed a cavitary image with its levels in the middle field of the right lung. No other lesion was evident (Fig 76).

After several months of non-specific treatment for the lung affection, the patient was discharged. The radiogram, at that time, revealed nothing more than a faint outline of the cavity (Fig. 77).



FIG 78 This picture was obtained when the patient was rehospitalized (Cont)



FIG 79 Direct radiogram taken previous to contrast exploration of the bronchus The arrows point to annular images (Cont)

A year later the patient was readmitted, because of a slight hemorrhage during an attack of grippe This was later repeated almost weekly He had no appreciable fever, and no pain He had a cough with bloody expectoration He had lost about ten kilos in weight and was compelled to lie on his back as any change in his position caused coughing and expectoration. Auscultation of the right lung revealed rhonchi and damp rales, heard most clearly at the angle of the scapula

A new radiogram was obtained (Fig 78), which revealed the ring-like

image in the middle field but without a level. The image was smaller, but the outline was more irregular. Various types of treatment were instituted and laboratory studies were made in the hope of discovering the etiologic factor. To this end, Professor Allende asked us to carry out a bronchial exploration.

The exploration was done in May 1941, two years and a half after the onset of the acute lung affection A radiogram taken previous to the bronchial exploration (Fig. 79), revealed no change in the bronchial picture.



FIG 80 Initiation of bronchial filling The only abnormality evident is a small stain within the field of projection, corresponding to the first lower lobe branches (Cont)



FIG 81. Continuation of the bronchial filling The inferior limit of the cavity is shown

The introduction of the opaque substance did not at first reveal the communication of the cavity with the bronchus. As may be seen in Fig. 79, at first the branches of the middle, inferior and superior lobes filled up and the only abnormality found was staining of the opaque substance between the projection of the first branches of the inferior lobe A moment later, as Fig 80 reveals, the opaque medium had reached the lower border of the cavity, but in very slight quantity.

In the course of the explor[illegible] later the opaque substance in the cavity, but [illegible] ograms 81, 82 and 83 show the two [illegible] dorsal decubitus.

A tomogram made after the contrast exploration revealed very clearly the outline of the cavity.

As hemoptysis and suppuration continued, Doctor Langer, without an accurate diagnosis but suspecting the existence of an air cyst, decided on surgical intervention

During the two stage operation a biopsy of the wall of the cavity was obtained. The report was, "portion having the appearance of bronchial wall,



Fig 82 Late image of filling showing the lower limit of the cavity (Cont)



Fig 83 Image in dorsal decubitus (Cont)

having a partly whole cylinder epithelium" This confirms the diagnosis of a congenital lung malformation, of the type called *air cyst*

Case 4 demonstrates clearly the possibilities of bronchial exploration in children as well as in adults

This patient was a year-old baby who had had a cough for a few months sometimes with whooping As clinical methods, laboratory investigation and radiology had failed to make an accurate diagnosis, the physician-in-charge requested a bronchographic study

Direct radiography of the chest, showed the cardiac shadow displaced to the right and the vascular pedicle evidently widened (Fig 84)

The same radiogram shows on the right side and from above downwards, a thick tracing that seemed to form a boundary In transverse position (Fig. 85), we may observe behind the heart shadow an abnormal trans-





Fig 84. The displacement of the heart shadow is evident, as is also the broadening of the vascular pedicle There is also an opaque tracing that crosses downward from above The heart shadow appears on the right side (Cont)

Fig 85 Image in transverse position An abnormal transparency well limited towards the front appears behind the heart shadow (Cont.)





Fig 86 1, common trunk for the upper and middle lobe, 2, upper lobe trunk, 3, middle lobe trunk, 4, lower lobe trunk, C, cavity within which the catheter S has penetrated The arrows indicate the air cyst (Cont)

Fig 87. Transverse position image; 2,

parency, having very definite outlines and occupying the complete projection zone of the lower lobe.

Anesthesia was not used, and by means of the bronchoscope a catheter was introduced into the trachea Exploration was effected by injecting a c c of iodized oil. Radiograms were obtained with very short exposure, time 1 50 hundredths of a second

The images obtained were conclusive as they brought into evidence a lung malformation characterized by the complete absence of the lower lobe, the space being occupied by a large multilocular cavity Furthermore the branches of the middle lobe did not originate from the main trunk along with those of the lower lobe, but from the same trunk as those of the upper lobe

In Fig 86 we see the first image obtained after initiating the bronchial filling, where the filling of the whole right lung is evident, formed only by the middle and superior lobes A portion of the cavity is also evident and part of the cyst is seen (Figs 87 and 88)

This unusual observation proves the value of early bronchial exploration in cases of lung pathology in children. By this means we may determine the origin of many diseases, that later on in the adult become acquired processes

The case just described can be classified only as a lung cyst, accompanied by an agenesia of bronchial segmentation that has caused the middle and inferior lobes to rise from the same trunk and the right main trunk to divide into two branches.



Fig 88 Late image of bronchial filling, showing the multilocular cavity which the catheter has penetrated The arrows indicate the cyst (End)

Case 5. *Suppurated and Operated Air Cyst* The following case shows not only the diagnostic difficulties but also the treatment in difficulties that may arise in this vast field of lung malformation

This man had had symptoms of lung origin since infancy (bronchorrhea and coughing). Shortly before he presented himself at the Tuberculosis clinic, these symptoms increased There had been no elevation of temperature

Radiographic examination (Fig 89) showed a large left cavity containing fluid and air This cavity had two levels, showing its multisaccular formation

While the patient was under observation, he was feverish, and his general condition became *rapidly worse* He was admitted to the hospital, where he was operated upon for a left pleural abscess His general condition improved after several months, and the chief of the service decided to per-



Fig 89 Picture of the left chest showing a large cavity having a double level Pleural cul-de-sac is free. (Cont)



Fig 90 Left chest, three years after plastic operation Two rubber tubes and a safety pin are observed (Cont)

form a total plastic operation, with the object of collapsing the lung and reducing the cyst.

Three years later the patient had a copious discharge from a thoracic fistula and

A radiog[illegible] the regeneration of the extracted r[illegible] tubes and a safety-pin. Transverse radiography brought into further evidence the two rubber tubes and the safety-pin, and a fluid level within a large cystic image

Tomography in transverse position, only to confirm the findings in the previous radiograms, that is, the presence of a cavity with fluid and air [illegible]'s cavity

a bronchographic study, the



Fig 91



Fig 92

Fig 92 Middle phase of bronchial filling, confirming the atrophy of the first ventral branches of the lower lobe (Cont)

Fig 93 Final phase No communication of the cavity with the bronchial tree is evident This communication is undoubtedly effected through a very narrow orifice (End)



Fig. 93

In these bronchograms we observe that the branches corresponding to the lower lobe, especially the first ventral branch, do not show normal characteristics, being replaced by an atrophic bronchus without secondary branchings

The course of the disease together with direct radiologic and bronchographic evidence lead us to this diagnosis, and with the object of extracting the foreign bodies retained in the interior of the supposed cyst, the patient was again operated upon

The site chosen was the thoracic fistula. The operation was attended with great difficulty on account of the vascularization surrounding the fistula Once the fistula was widened, forceps were introduced by means of which a large rubber tube was extracted It was one of those used for drainage, doubled in two, which explained the appearance of two tubes in the radiogram. The safety-pin could not be extracted as it was imprisoned in the walls of the cavity.

The endoscopic examination of the cavity revealed a smooth brilliant surface, having the characteristics found only in epithelium. It was, therefore, really an air cyst that had been opened and drained. This treatment is dangerous as it may cause a fatal hemorrhage and its plastic operation that followed could not effect the collapse of the cyst. Only lobectomy could have been of benefit before performing the plastic operation.

Bilateral Alveolar Agenesia

This malformation may involve both lungs and may limit the

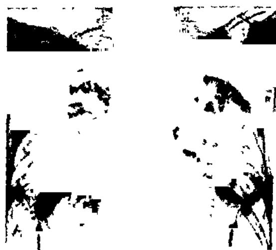


Fig 91. Radiogram showing the appearance of both lungs in a case of alveolar agenesia. (Cont)

possibility of existence. The case we are about to report is that of a man who had been a farmer since youth. He had always had trouble with his lungs He had suffered from *pneumonia and broncho-pneumonia*, without his general health being impaired. During the past five years, due to the increased expectoration and coughing, he sought the aid of several specialists, who ordered a sputum examination However, neither this measure, blood tests, nor skin tests were of any help in establishing an accurate diagnosis

The direct radiogram reproduced in Fig 94, shows a very dense opacity of the whole lung field Multiple ring shaped images of various size, are clearly apparent The seventh and eighth left ribs had been fractured in their posterior third, but the patient did not remember the accident nor did he complain of any pain in that region The two arrows indicate a union of the incisura major with the diaphragmatic pleurae, where they form *a tent*.

Fig 95 is a bronchogram showing the apparent scarcity of secondary branching and an extensive alteration in the conformation and size of these branchings, as well as the complete absence of foliage shown by the replacing of the alveoli by ampullar cavities A great quantity of pus completes the disfiguration of the bronchial tree



Fig 95 Bronchogram of same case showing an absolutely abnormal picture A scarcity of branching exists as well as expansion of branchings with the glove-finger endings (End)

In this patient were found the classic signs of alveolar agenesia, together with those of the air cyst, that is, two processes that have their origin at different periods of embryologic development, but having the same etiology.

The majority of patients suffering from lung agenesia present a picture similar to this one, in which we find two or more types of malformations existing simultaneously.

Unilateral Alveolar Agenesia

Incomplete alveolar agenesia of the bronchial tree is also characterized by formation of the bronchial branches, but with complete absence of the fine branches and acini. Furthermore *only* one lung is affected.

The following case shows a radiologic view of this type of malformation.

This patient presented the clinical picture of a lung abscess. From



FIG 96 Appearance of the left lung in a direct radiogram taken with increased time of exposure with the object of selecting opacities (Cont.)



FIG 97 Tomogram of the same case, where the numerous annular images that perforate this shadow are better distinguished. (Cont.)

infancy he had suffered from extreme respiratory difficulty and had been susceptible to colds. He had always had expectoration and coughing, even when he considered himself in good health.

We examined him 20 or 25 years after the apparent onset of his actual illness.

Radiogram 96, *shows* the left lung *completely* filled and within this opacity we may observe multiple annular images. The trachea

has been deflected and the heart shadow is not evident within the opacity. Nothing abnormal is observed in the right lung.

Tomography, of which we may see one plane in Fig. 97, confirmed the presence of these multiple annular images, which appear as openings within the opaque mass. Contrast exploration, however, revealed clearly the profound changes in the bronchial architecture, as



FIG 98 Bronchogram obtained in left lateral decubitus, showing the scarcity of secondary branchings and the presence in the bronchi of ampullar expansions ending in a *glove finger*. (Cont.)



FIG 99 Bronchogram obtained in supine decubitus and oblique direction, showing the profound changes in the left lung (End.)

shown in Figs. 98 and 99. The principal branches have not changed greatly but the secondary and third degree branchings are few, are greatly increased in size and end in ampullar expansions that fill easily with the iodized oil Fig. 98 was made in left lateral decubitus and Fig 99 shows the radiogram obtained in supine decubitus and oblique direction.

Cystic Bronchiectasis

Under this generic term we include bronchial deformities that affect the end of the branch where they cause an ampullar or cystic expansion We include in this group the so-called *sacciform bronchi-*



Fig 100 Direct radiogram showing the criss-crossing of many annular images, principally in the upper right field (Cont)



Fig 101 A and B are tomograms showing the polycystic condition of the upper right lobe (Cont)

ectasis and polycystic lung. The clinical symptoms and the history of these patients vary greatly. Some complain of having had bronchorrhea and asthma since infancy, and others only after a discharging lung process. In other patients, agenesia has not become manifest, but has remained quiescent until discovered on radiologic examination Thus our attention is called to the contrast that exists between extensive lung lesions and clinical symptomatology

The radiologic image is characterized by the presence of numerous annular images that occupy various regions of the lung, but most commonly a complete lobe This annular image had a clean cut outline, sometimes having the tracing of a level in its interior. The size of the images varies, but they rarely are over 3 cm. in diameter. They are more frequently grouped than isolated and they expand on inspiration and contract on expiration

Radiologic exploration of these images, by tomography or by the contrast method gives conclusive diagnostic pictures.

In the following cases we shall describe this radiologic symptomatology in detail The first is a case of the so-called polycystic lung.

Case 1. This patient had complained for several years of bronchorrhea and dyspnea One of these attacks was in progress when she sought medical aid

Direct radiography showed (Fig 100) an absolutely abnormal pictur revealed by multiple annular criss-cross images, especially in the righ apex, with emphysema in some areas

It was tomography, however, that brought into evidence the multicystic or cavitary constitution of the right apex As may be seen in the two tomograms represented in Fig 101, many cysts fill the whole upper lobe

Contrast exploration only confirmed what tomography revealed, showing concretely the conformation, number and situation of the bronchial branches and the changes that had taken place

The serial record of the bronchial filling of the upper lobe showed that the anatomical changes, although predominant in the upper lobe, also existed in the middle lobe and were fewer in the inferior lobe In panoramic adiograms taken in the standing position, the multiple dove's nests are learly evident (Figs 102, 103 and 101) This case should be classified, in ur opinion, as a *polycystic lung*

Case 2. The history and record in the following case demonstrates very arly the characteristics of polycystic lung This patient was a man thirty rs of age, who had been really ill for two years He finally decided to place self under the care of the physiologist, Dr Ortiz During childhood and th, this patient was healthy almost continuously, having had measles at



FIG 102 A, B, and C, different aspects of the serial record of bronchial filling, showing the extensive alteration in the bronchial architecture (Cont)



FIG 103 Panoramic view of the bronchial filling of the right lung in standing position and frontal incidence Numerous *dove's nest* images are seen. (Cont)



FIG 104 Panoramic view in transverse position, confirming findings of frontal position and showing the lobular location of the images (Cont)

the age of 8 and an intestinal complaint of short duration at the age of 22 Two or three years previous to seeking medical aid he noticed an increasing tendency to become fatigued, weakness and loss of appetite He had expectorations first only in the morning but later during the whole day. He had no fever His weight remained stationary, but his lung complaints went through cyclic periods of improvement and exacerbation Examination revealed a predominant symptomatology in the middle field and the base



Fig 105 A honeycomb-like image in the middle field of the left lung (Cont)



Fig 106 Tomogram of the same case, clearly showing the characteristics of the honeycomb with thickened walls and cells of varying size (Cont)

of the right lung, characterized by bronchoalveolar sounds and auscultatory murmurs Nothing abnormal was found on percussion.

Direct radiography showed that in the middle field of the left lung was an area having the appearance of a honey comb with large cells. In the right base as well as in the left radiologic signs of bronchiectasis were evident (Fig 105)

A tomogram of this area reproduced in Fig 106, showed more clearly the honey comb characteristics, namely, thickened walls, and cells of unequal size The clear outlines of this honey comb were also evident

The contrast radiologic exploration revealed that these multiple annular

images of the left upper front lobe, had difficulty in communicating with the bronchus, due, in part, to the fact that the communicating orifice was narrow, and also because the secretions filled the cavities and bronchial channels. In the cavities where the opaque substance has penetrated, the mixing of the iodized oil with the secretions is evident, accounting for the absence of true *dove's nest* formations (Fig. 107 and 108).

The neighboring branching is greatly altered as to quality, calibre, and



FIG 107 Initiation of bronchial filling showing the alterations in the branchings and ampullar expansions filled with opaque substance and secretions (Cont)



FIG 108 Intermediate phase of filling, confirming the findings already mentioned (End)

lack of foliage On account of the patients' extreme dyspnea, exploration of the right lung base showed only a cylindrical bronchial expansion, indicating a lung abscess.

Bronchography was difficult in all these cases because of the incomplete filling [illegible]

In [illegible] *ectasis*, annular image [illegible] itrary to what we have just seen, the opaque substance penetrates easily.

Case 3. This patient is 20 years old. Since childhood he has complained of intermittent coughing and expectoration. He had had asthma and a lung abscess At the time of admission he had no fever but he had had it at

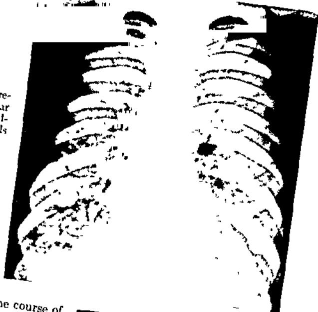


FIG 109. Radiogram revealing numerous annular images in the base and middle lung field Some levels are observed (Cont)

different times During the course of his illness his general condition remained about the same and no Koch bacilli were found in sputum

Fig 109, shows the radiologic image of his lung The base and middle field of the right lung present numerous annular images, some of which show a fluid level

Tomography in Fig 110 clarifies these images

Bronchography, however, brings out most clearly the extension and characteristics of this agenesia As may be seen in Figs 111, 112, and 113, the normal characteristics of branching and foliage have disappeared, being replaced by cylindrical and ampullar distention of the bronchi.



FIG 110 Tomogram of the same case, clearly showing the numerous annular images and their fluid content (Cont)

With the patient in oblique and dorsal decubitus positions, the opaque substance is mobilized to form images that have been called by expressive names, such as *dove's nests*, *bunches of glicina*, *bunch of grapes*, *etc*



Fig 111 Bronchogram taken in standing position The terminal ampullar expansion of the branches is observed, as well as the lack of foliage and neighboring emphysema (Cont)



Fig 112 Picture in right lateral decubitus The dove's nests are clearly seen, as well as the general characteristics of the malformation (Cont)



Fig 113 Image in dorsal decubitus. Image resembles a bunch of glicinias

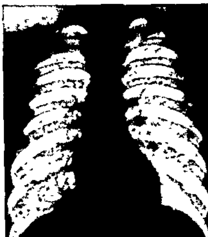


Fig 114 Radiogram of case 4, showing numerous annular images in both lung fields, but especially in both bases (Cont)



Fig 115 Bronchogram showing the initial phase of alveolar filling (Cont)



Fig 116 In this bronchogram, the terminal expansions of the bronchus are seen together with the absence of foliage and fine branchings (Cont)

Case 4. *The following* case shows how greatly clinical symptomatology and the patient's history may differ from radiologic findings. This patient is 52 years old, has never had a severe illness, has never consulted a doctor except for chronic *bronchitis*, which periodically became acute. His reason for coming to the Rawson was to have an x-ray of his chest in compliance with a Public Health



Fig 117. Another view of final filling phase of bronchial tree Here the alterations become more evident (Cont)



Fig 118 The same case seen in transverse position (Cont)

could be observed within those annular images During inspiration these annular images showed a characteristic expansion and became contracted during expiration The elasticity of the walls of the cavity proved that it was formed by vesicles of congenital origin for no other destructive process could assume this formation. What really revealed the deep and extensive alterations of the bronchial architecture, however, was bronchial exploration by the contrast method as we may see in the following pictures.

Fig 115 is a view of the canalicular filling of the right lung, more complete in the branches of the middle and lower lobes. The increased calibre, irregular outline and poor secondary branchings of the bronchial tree, are shown

Figs. 116, 117 and 118 show ampullar expansions communicating with the bronchi, in place of the normal foliage Normal foliage is almost absent in this region and the scarcity in fourth and third order branchings is manifest.

Suspecting that the lesions found in the right side were also present in the left, as the direct radiogram gave the same indications, an immediate left bronchography was decided upon.

Fig 119 shows the canalicular aspect at time of filling of the bronchial



Fig 119 Canalicular view of the left bronchial tree The branching appears more normal than that of the right side (Cont)



Fig 120 Appearance of the bronchial tree during final phases of filling Note ampullar expansions and absence of foliage and fine branchings (End)

tree The alterations in the large and medium trunks are not as evident as in the right side Fig 120 corresponds to the final alveolar filling phase, and here it is evident that if the canalicular alterations of the bronchial tree are fewer in the left side, the terminal alterations of the branches are just as intense Here also we find the ampullar expansions in communication with the bronchi, together with the poor fine branchings and absence of normal foliage

Only congenital deformities could cause such gross deformities of the bronchial tree in view of the negative history of the patient. These deformities may remain unsuspected by the patient, his family and his physi-

cian. This case is similar to that of polycystic lung, but we prefer to keep this name for those cases that have this same appearance in direct radiograms, but in which the opaque substance *does not penetrate the interior of these cavities*, or penetrates with difficulty. The present case corresponds to the one classified as *sacciform bronchiectasis*.

Case 5. Let us observe a case which proves that these two processes,



Fig 121. Numerous annular images are observed covering the right lung (Cont)



Fig 122. Similar images in the left lung (Cont)

polycystic lung and bronchiectasis, are only phases of the same congenital picture, as both may be found simultaneously in one patient.

This case resembles Case 4 with one exception; although it presents, in the direct radiogram, a similar appearance in the right and left sides, bronchography shows that image of the bronchial tree on the right side is of sacciform bronchiectasis and in the left that of a polycystic lung

The clinical history is the same as that in the previous case. The patients believe they have chronic bronchitis or asthma or they are "*weak-lunged*"

Fig 121 shows a view of the right chest, where multiple annular images may be observed covering the whole lung Fig. 122 shows similar images in the left lung



Fig 123 Image of the filling phase of the right lung base (Cont)



Fig 124 Late image revealing the communication of the bronchial branches with the cysts (Cont)



Fig 125 Late image of contrast exploration, showing the numerous dove's nests (Cont)



Fig 126 Initial image of the exploration of the left side The changes in calibre and outline are evident as well as the sparse secondary branchings (Cont)



Fig 127. Image of intermediate phase of exploration The iodized oil does not penetrate the cavities (Cont)



Fig 128 Final phase of bronchial exploration in the left side, showing that the opaque substance has not penetrated the cystic cavities (End)

Bronchography reveals, that the bronchial tree in the right side is very different from that on the left, as serial radiograms shown in Figs 123, 124, and 125 attest These radiograms correspond to the right side, and Figs 126, 127 and 128 correspond to the left side Figs 123 and 124 show the

Fig. 125 shows the final view after the contents of the branches have been evacuated; then the multiple dove's nests become quite clear In the left side the initial images of the bronchial fillings are very similar, but the final view (Fig 128) is quite different Here the iodized oil has penetrated in very small quantity and only into very few of the cysts

and may co-exist or follow one upon the other.

Bronchial Diverticulum

When the bronchial tree is developing, sprouts may appear that if retarded in their growth, later appear in the bronchogram as



Fig 129 Bronchogram of the diverticulum



Fig 130 Tomogram of the same case

"glove-fingers" or diverticula. These bronchial outlines appear localized in the site that corresponds to the normal growth of bronchial branches in animals. For this reason they have the character of an inherited agenesia.

We had the opportunity of observing one of these anomalies in an adult patient with chronic left pleurisy. A contrast exploration was carried out with a view to ascertaining the dynamic state of the affected lung. A diverticulum 1 cm. long was seen, originating in the middle part of the intermediate left trunk. Later a tomogram confirmed the presence of this anomaly (Figs. 129 and 130). It has no pathologic significance.

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CHAPTER IX

Bronchiectasis

ETIOLOGY

From a study of patients affected by bronchiectasis, we may conclude that numerous factors are involved in its origin. Infrequently these factors occur individually but as a rule they are combined. Some of these factors may be absent in cases of bronchial expansion, but there is one, that in our opinion is always present and is responsible for the ectasis.

Before considering this factor, let us briefly review the accepted theories regarding the etiology.

The most generally accepted theory is that expansion of the bronchial wall is due to an infection that destroys its elasticity. This theory is based upon the fact that a certain degree of infection accompanies every bronchial expansion and more or less completely destroys the bronchial wall.

This theory of infection may be as follows. Histologic studies prove that in addition to expanded bronchi having thin walls due to infection, there are others equally expanded but having walls that are only slightly affected or they may be undergoing a process that causes thickening. It is therefore not only the destruction of the bronchial wall that conditions ectasis.

Another theory maintains that it is not only the isolated factor of infection that causes bronchiectasis, but that the presence of secretions is also essential as the latter are the direct cause of expansion through the pressure they exert upon the bronchial walls already weakened by the infection We may dismiss this theory by stating that the secretions are not absolutely necessary for the formation of the ectasis, for extensive bronchial expansions are observed with scarcely any secretions. They are cases of "dry bronchiectasis" that every clinician has had an opportunity of observing, or there may be long dry periods in bronchiectasis patients that in no way lessen the degree of bronchial expansion.

The clinician is also familiar with severe bronchorrheas that have not caused bronchiectasis.

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Nor do modern methods for removing the secretions and for bronchial lavage heal the bronchiectasis as this theory would lead us to believe. Moreover, the ectasis is present also in the upper lobes where secretions are minimal.

A third theory suggests as an etiologic factor, the retraction of the lung tissue surrounding the affected bronchus. This would occur in a case of peri-bronchitic pneumonitis. This theory explains satisfactorily the final phases of bronchiectasis, when next to the expanded branches there exist obstructed bronchiolites that cause atelectasis or when the infectious process has progressed beyond the limits of the bronchial sheath (Peribronchitis) The fact is that during the initial stage of bronchiectasis, there are no neighboring changes that could influence the conformation of the bronchial wall which still retains its sheath, muscular and elastic fibres and its cartilage intact; that is, it retains its normal resistance.

Bronchial obstruction has long been regarded as the fundamental cause for ectasis. Since 1833 when Reynard mentioned this cause for the first time, numerous authors have suggested various causes for partial bronchial obstruction, foreign bodies, tumors, scar tissue, etc. This theory of obstruction, however, can not account for the initiation of ectasis in those patients in which no cause for mechanical obstruction is found, for instance in post-whooping-cough bronchiectasis, or after measles, in bronchiectasis of allergic patients with or without sinusitis As has been mentioned, the presence of secretions would be a factor in this variety of obstruction but we have already pointed out that secretions may disappear or be non-existent and yet bronchiectasis persists.

Our bronchial examinations with contrast media have brought up new arguments in favor of this theory and we believe that we have found the missing links in a theory of the etiology of bronchiectasis that is in agreement with clinical, anatomical and radiologic facts.

In our opinion, ectasis is due to an obstructive syndrome. In order to evaluate this opinion it is necessary to understand bronchial anatomy and physiopathology, as we shall point out later. This obstructive syndrome consists chiefly in difficulty of expiration of air from the bronchus causing a temporary increase in pressure that acts like a heavy blow and is repeated more than 16 times per minute, or 1000 times an hour, about 24,000 times a day. In the act of coughing, that is, in forced and multiplied expiration, this blow is

greatly intensified and has the physical effect of an explosive high pressure.

This extreme pressure first weakens the alveolar tissues and emphysema appears. When the expiration obstruction persists or progresses on account of infection, edema in the mucosa and the secretions, the bronchial wall begins to give way first in those portions that are less rigid, that have no cartilage, and then in the firm architecture For this reason bronchiectasis is always more intense at the end of the bronchial branches, because they are in an unfavorable anatomic position to resist the expiratory blow

Infection, edema of the mucosa and the secretions, finally obstruct the terminal fine bronchi, and micro-atelectasis then appears which in the direct radiogram assumes that speckled appearance that is so characteristic of the radiographic image in bronchiectasis This obstruction is in part responsible for the lack of "foliage" in the bronchographic image, although we must not forget that the absence of fine branching and foliage is also due to the weak thoraco-alveolar aspiration that is an obstacle to filling

These findings explain the fact that we may find emphysema without bronchiectasis, but not bronchiectasis without emphysema. Both processes are due to the same cause, bronchial obstruction and the consequences will vary according to the localization of the obstruction

When the obstacle to expiration is in the respiratory bronchioles (due to the spasm of the sphincter of the alveolus for instance), the only manifestation will be emphysema, when the obstacle is in the bronchi themselves (on account of a spasm of the truncular sphincter for instance) then the first manifestation is emphysema but this is followed by bronchiectasis if the obstacle persists.

The obstructive syndrome is therefore simple in its initiation Later ıfection destroys the bronchial wall, transforms the epithelium, the astic fibres, muscles, cartilage and the sheath so that they are no nger recognizable, and then the expansion becomes great and the structive syndrome, as such, disappears, giving place to infection such an organic character that it masks the functional syndrome t is essentially dynamic.

his obstruction may be only functional or it may be organic and d. Its role in the etiology of bronchiectasis may be primary, ting the infection and consequently the destruction of the

bronchial wall, or it may be secondary to the infection and the anatomical changes in the wall.

The bronchial obstruction may be due to *functional* or *organic* causes, thus:

- Functional
  - Permanent
    - By local irritative stimulus
    - By intensification of central order tonus or by reflex
  - Transitory
    - By expiration
    - By coughing
- Organic
  - Extra-bronchial
    - Sclerosis
    - Ganglions
    - Tumors
    - Aneurism
    - Hydatid Cyst
  - Parietal
    - Benign or malignant tumors
    - Retractile ulcers
    - Embedded bronchiolites
    - Incysted foreign bodies
  - Canalicular
    - Free foreign bodies
    - Secretions
    - Mucous stop

Let us now analyze these suggested factors.

The Truncular Sphincter

The increased tension of the functional sphincter at the origination of the bronchial branches is a predominant factor in the obstruction causing bronchiectasis. This truncular sphincter that has been sketched by Miller according to his anatomical observations is formed by muscular and elastic fibres that surround the root of a branch like a loop.

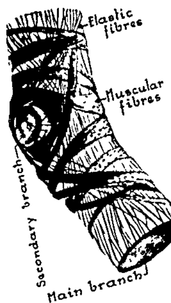


FIG 131 Truncular sphincter strangling the root of bronchial branches when it contracts Its muscular fibers are innervated by the pneumogastric nerve According to W. S. Miller



FIG 132 A and B Variations in the bronchial calibre during respiration The calibre increases during inspiration and diminishes uniformly during expiration

As may be seen in Fig. 131, the contraction of these fibres causes an angular strangulation of the bronchial branch, which may completely obstruct it.

Normally, during inspiration, these fibres relax and during expira-

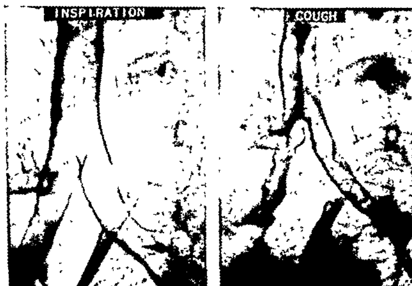


FIG 133 Variations in the form and calibre of the trachea and main bronchus during coughing In addition to reduction in calibre a longitudinal crumpling up of the right main bronchus occurs The oesophagus remains still

tion, they contract, accompanied by general contraction of the bronchial muscular fibres during the act of respiration. This synchronization between the relaxation of the fibres and inspiration also occurs with the expansion of the chest and can be obtained by means of artificial respiration (Fig. 132 and 133).

In pathologic conditions when the tone of these fibres is increased, contraction during expiration becomes so energetic that the strangulation of the bronchial root begins, causing retrograde hypertension

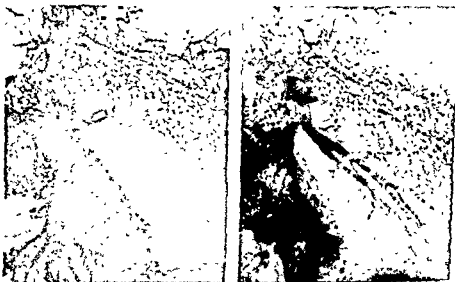


FIG. 134 Truncular spasm causing complete closure of the main middle lobe bronchus Increasing anesthesia caused this spasm to disappear.

of the airways, and as a consequence, expansion of the alveoli, or in other words, *emphysema*, and expansion of the bronchus or *bronchiectasis*

We insist in the necessity of going over the last part of Chapter IV, especially the part dealing with the physiopathology of the cough.

Brown Sequard (1) was able experimentally to produce emphysema by stimulating the pneumogastric nerve causing a spasm of the bronchi, thus creating the syndrome of a functional obstruction that caused expiration hypertension This experiment emphasizes the significance of the pneumogastric nerve in the etiology of dyspnea, emphysema and bronchiectasis.

[1] Brown-Séquard—Indication d'un mode nouveau de production d'emphysem pulmonaire Comptes Rendus des Seances de la Societe de Biologie—1885

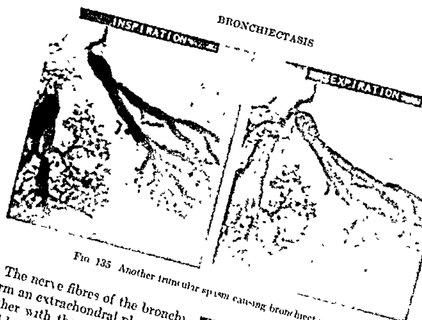


Fig 135 Another truncular spasm causing bronchiectasis

The nerve fibres of the bronchi form an extrachondral plexus, together with the vascular sheaths and have their origin in the sympathetic nervous system. Those of the sub-chondral and sub-epithelial plexis come from the lower branches of the pneumogastric nerve and transmit the stimuli received from the free terminal nerves in the epithelium, or motor impulses, toward the muscle fibres.



Fig 136 Truncular spasm of the main lower bronchus in a patient operated upon for a hydatid cyst The spasm has caused a channel apparently of organic origin (Cont)

The role of this nervous sys-m is particularly important whooping-cough and allergic tes where there is hypersensi-ness and congestion of the chial mucosa that acts as a ulus, multiplying the effects e functional hypertension of the trunk sphincter Fig 134. these cases all the bronchial branches have a reduced calibre ersistent absence of normal physiologic respiratory dynamism,

showing at their root evident strangulations. Figs. 135, 136, 137, 138, and 139.

It is the elastic and muscular fibres that cause the rigidity, reduction in calibre and truncular strangulations of the bronchial branches. They are excited by nervous fibres which have been stimulated by hypersecretion, congestion and infection. This vicious circle may be interrupted in any of its phases; therefore, any treat-





FIGS 137 and 138 Late examination of the same patient showing the disappearance of the spasm but the persistence of the strangulation of the lower main trunk, particularly during expiration The lower arrow points to a strangulation of a branch during expiration and below it the initial ectasis of the branches

ment intended to reduce the threshold of neuromuscular excitability, may be of temporary benefit, whether it is done by reducing congestion or by limiting the infection. That is why various types of treatment for bronchiectasis usually produce a passing beneficial effect until the vicious circle re-establishes itself.

The Foreign Body

The functional obstruction caused by the foreign body serves as an experimental demonstration of the importance of this mechanism in the etiology of bronchiectasis. The term "foreign body" denotes

those bodies that actually come from outside the body and consist of solid element, as well as those that arise in the interior of the bronchi (tumors and bronchiolites) and that act in the same manner as extravenenous foreign bodies. The interbronchial foreign body causes the obstruction as much by its presence, which partially obstructs the lumen, as by the direct irritative spasm of the mucosa that it provokes or the secondary infection that develops immediately afterwards. This obstruction is manifested first by emphysema, and when bronchial obstruction becomes complete it is expressed by atelectasis.

For bronchiectasis to occur the bronchial obstruction must have persisted over a prolonged period so that the infection has altered the bronchial wall and made expansion easy.

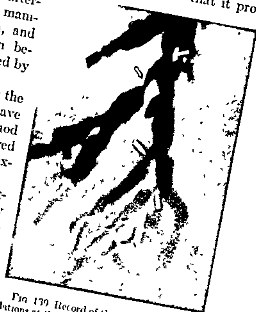


Fig 139 Record of the numerous strangulations at the root of the branches in the case of bronchiectasis

For the roentgenologic diagnosis of emphysema caused by bronchial obstruction it is necessary to obtain the radiograms precisely at the final moment of expiration, for the contrast between the very permeable lung areas which expel the greater part of the residual air and those that are semi-permeable and permit only the expulsion of a small quantity, is most evident at that moment. By this means we are able to discover initial stages of emphysema that pass unnoticed in the usual radiogram made during inspiration.

Barcia (Montivedeo) and Overholt (Boston) have proved this clinically, the former in the case of a true foreign body and the latter in a case of bronchial cancer

Extrabronchial Compression

Compression of the bronchus from without can cause obstruction to the column of expired air and initiate, by means of hypertensive repercussion, ectasis of the alveolus or the bronchus. *Adenitis* of any

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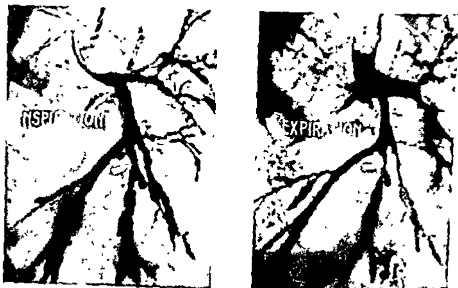
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Fig 139 Record of the numerous strangulations at the root of the branches in the case of bronchiectasis

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Extrabronchial Compression

Compression of the bronchus from without can cause obstruction the column of expired air and initiate, by means of hypertensive percussion, ectasis of the alveolus or the bronchus *Adenitis* of any

type, *tumors, aneurysms, hydatid cysts,* compress the bronchial wall, reduce its lumen and create the obstruction that causes emphysema and bronchiectasis. In our opinion, it is this mechanism that explains the *perihydatid bronchiectasis* and *pneumo-pericystitis. Perihydatid bronchiectasis* is due to the obstruction caused by external compression of the cyst upon surrounding walls of the bronchus. Exploration

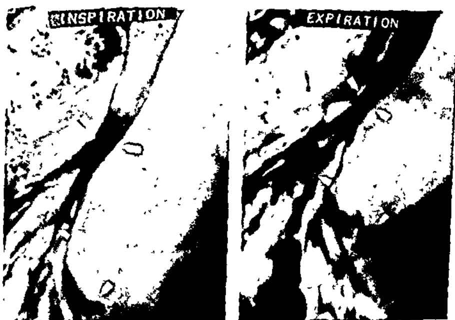


FIG 140 Extrabronchial compression of the basal trunk of the right bronchial tree. In the bronchogram obtained during expiration, the reduction of the bronchial lumen causing the obstruction and initiating the ectasis, is evident.

with a contrast medium has brought this compression clearly into evidence, as well as the flattening and dislocation of the bronchial branches due to the eccentric growth of the cyst (Fig. 140).

The *pneumo-pericyst* is really an emphysema that surrounds the germinative layer of the cyst. The air penetrates through some of the bronchioles that are included in the pericyst or even through broken alveoli, and due to a valvular action this air cannot get out as it accumulates, it loosens the germinative membrane of the pericyst If this valvular system becomes obstructed, the air is re-

absorbed and the pneumo-pericyst disappears and both membranes again come into contact.

Infection

The infectious process acts in various ways to cause bronchiectasis and is always associated with the obstructive syndrome. In chronic bronchitis the infectious process is initiated by irritation of terminal nerve endings of the endobronchus. This irritation produces the spasm of the bronchial musculature which causes the reduction of its calibre, especially at functional sphincters, or in other words, at the root of the bronchus (truncular sphincter), thus creating the bronchial obstruction necessary to produce the ectasis. This nerve irritation also causes hypersecretion which in its turn contributes to reduction of the bronchial lumen, thus causing difficulty in expiration. Localized infectious processes such as ulcerative or vegetative tuberculosis, syphilis, mycosis, etc, may also cause an obstruction in the air-ways that by the same mechanism may produce bronchiectasis.

This obstruction may occur during the course of a tuberculous, mycotic or syphilitic infection, or may be due to a retractile scar after the infection has passed In addition to these cases in which infection constitutes the primary cause, we also see cases in which *infectious process is secondary to the obstruction* whether this is a foreign body, an endobronchial tumor, external compression or simple obstruction caused by functional hypertonicity of the truncular sphincter This infection is aggravated by difficulty in expiration, by the retention of secretions and by congestion or ectasis. In brief, infection causes *bronchitis* but not the expansion of the bronchus Ectasis is due to a dynamic action caused by hypertension of the air column during normal expiration or in the forced and multiple expiration during coughing. Various intervening causes have been observed in which case we see an interaction of factors that contribute to the ectasis but of these the obstructive syndrome, whether it appears first upon the scene or later, always plays the chief role.

BRONCHOGRAPHY IN CHRONIC BRONCHITIS AND BRONCHIECTASIS

Chronic Bronchitis

During the initial period of chronic bronchitis the bronchographic picture is varied In addition to distended branches, others of greater

than normal diameter are found. This is due partly to anatomic lesions of the wall, and in part to the nervous alterations that modify the tone of the bronchial wall. That is why ectasis combines with bronchoparalysis and bronchospasm.

During this period the reflexes are exaggerated, and for this reason, secretions are less for they are continually being eliminated.

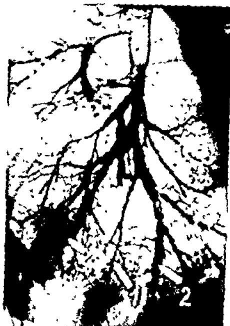


FIG 141. Bronchogram of a chronic bronchitis at the initiation of the ectasis There are signs of bronchospasm (arrow 1) and of bronchiectasis (arrow 2) Normal (arrow 3) (Cont)

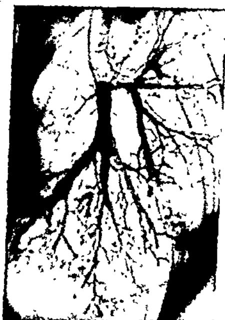


FIG 142 Same case, left side exploration Here we see lesions similar to those existing on the right side (Cont)

Figs 141 and 142 are bronchographic pictures of one of these cases of chronic bronchitis in its initiation stage. Direct radiography showed nothing significant but bronchography revealed signs that left no doubt about the anatomical and functioning state of the bronchus. In Fig. 141 we see typical lesions of the bronchial wall. Arrow No. 1 shows one of the branches *undergoing a bronchospasm with* resulting decrease in its lumen as compared with that of normal branches. (Arrow No. 2 points to branches that reveal all the signs of ectasis and bronchoparalysis.)

Local and general medical treatment sometimes has a very favorble influence on the anatomy and dynamism of the affected organ. In this case bronchography is useful to follow the course of the progress, and as the opaque substance is completely eliminated within three months and this is also a suitable period of treatment, the exploration may be repeated without difficulty.

This same patient, whose case is represented in Figs 141 and 142,



Fig 143 Bronchogram of same patient as in Fig 141, obtained three months after medical treatment The bronchospasm has disappeared, the fine branches are more numerous and the foliage is more regular (Cont)



Fig 144 Findings from exploration in the left side after three months treatment The bronchial picture is now almost normal (End)

was submitted to bronchoaspiration and bronchial lavage by Doctor R. L Castelli. After three months she was again explored with the results observed in Figs. 143 and 144 In Fig. 143 the bronchospasm pointed out in Fig 141 has disappeared. Secondary branching is more abundant and foliage more regular. The characteristics of the bronchial tree are now approximately normal. In the left side (Fig. 144), favorable changes have also taken place, but as this side was less affected, the contrast between the explorations is less.

Intermediate Period

After chronic bronchitis has led to degeneration of the bronchial wall so that the process has become generalized, the signs of ectasis begin to predominate over those of spasm as shown by bronchography. During this phase the secretions are more dense, they are retained longer in the canals due to the loss, in the most affected area

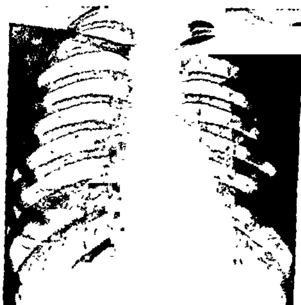


Fig 145 Direct radiogram showing slight changes in the lung reticulum. (Cont)

of the cough reflex, therefore the suppuration images are more frequent. The conformation defect of the branches accompanies the frequently interrupted column of opaque substance due to the retained pus. As the most affected branches lack the normal dynamism, due to bronchoparalysis, it happens that the air is not displaced in a normal manner from the bronchial lumen to the exterior, and when the opaque substance arrives it compresses the air like a piston, thus causing obstruction images at the branch endings.

During radioscopy this obstruction is very clearly differentiated from obstructions originated by secretions, for, while the air bubble

rises rapidly on account of its lower density, the purulent bubble rises slowly, and we may observe its progress from the lower areas where it is displaced by the opaque substance to the upper ones where it floats.

A record of this phase of chronic bronchitis may be seen in Figs. 145 and 146. This patient suffered from a bronchial process for several years, progressing gradually from the *asthmatic* stage to that of



Fig. 146. Bronchogram of a patient with chronic bronchitis in quiescent stage. The arrows point to shadows caused by pus and air bubbles. (Cont.)

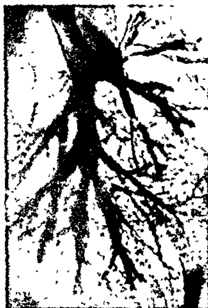


Fig. 147. Bronchogram of left lung of same patient. The signs of cylindrical expansion are more evident. (End.)

bronchorrhea. Fig. 146 shows the bronchial aspect of the right lung, several expanded branches stand out, especially in the base, and the abundant secretion is shown retained at the bottom of the branches or being expelled.

Fig. 147 is a bronchogram of the same patient. This is the left lung, where evidence of expansion of the bronchus is stronger not only in the posterior lower lobe branches, but also in the upper branches. This proves that bronchiectasis is not due to the *pressure of the secretion* and that it is not exclusively of the lung bases, but that it

is the result of the anatomic and functional transformations caused by the chronic inflammatory process in the bronchial wall affecting the whole lung. Naturally in the areas where the secretions are deposited, the phenomenon is emphasized.

Poverty of fine branching and foliage may be noted in the initial phases accompanying cylindrical expansion of the branch. As the anatomopathologic process becomes intensified, both disappear completely.

In these final aspects of chronic bronchitis we see a characteristic bronchographic picture. The lung space is furrowed by thick bronchial branches having abundant secretion and complete absence of the fine branching and foliage.

Final Period

The final picture of the chronic bronchial processes is very clear. Both clinically and radiologically, it has a characteristic aspect, so that the differential diagnosis is easy.

Clinically the patient has passed from the coughing stage to that of bronchorrhea and despite his morning bronchial cleansing, he expectorates without the effort of coughing continuously during the day. The clinical picture varies but the periods of apparent recovery do not return, as usually happens in the sub-acute stage.

Direct radiologic exploration provided very doubtful data since although we see the hive caused by ectasis especially at the base, it is not possible to make a definite diagnosis. For example, Fig. 148 is a direct radiogram of a patient affected by chronic bronchitis for several years and in the process of an attack at this time. In this bronchogram, especially in the right base, the image of a bee-hive determined by superposition of the bronchial ectasis is evident.

Nevertheless, bronchography gives us unquestioned findings.

In Figs. 149 and 150, the appearance of the bronchial tree at the beginning and end of filling is observed. Increase in calibre of large bronchi, the great amount of pus, the absence of fine branchings and complete loss of foliage is evident. This aspect may be seen in the base as well as in the upper right lobe. The left lung also presents the same picture (Fig. 151).

A comparison of these stages of chronic bronchitis, is very interesting and although not obtained in the same patient, we neverthe-



Fig 148 Direct radiogram showing honeycomb appearance of right base, caused by bronchiectasis (Cont)



Fig 149 Initial bronchographic aspect of chronic bronchitis in its final stage (Cont)



Fig 150 Intermediate phase of bronchial filling The absence of fine branching and foliage is evident, as well as the presence of pus in the alveolar ducts (Cont)



Fig 151 Appearance of the bronchial tree in the left side, which is the same as the right (End)


A


B


C


D

less present the successive pictures of the bronchial tree affected by this process (Fig 152).

Moniliform Bronchiectasis

A variety of cylinder ectasis, is the so-called moniliform expansion, in which the air tube does not expand regularly, but presents bulgings



Fig 153 Radiogram of the right chest showing an opaque base with multiple small cavities (Cont)



Fig 154 Initial phase of bronchial filling Some spasm with expansion of branches is observed The irregularity of the calibre is apparent (Cont)

that give the opaque bronchus the appearance of a rosary In this type also a chronic inflammatory process has led to the degeneration of the bronchial wall, and by a mechanism not well known, the disease acquires the moniliform appearance

Fig. 153 is a view of the right chest of a patient affected by a chronic bronchorrheic bronchitis. The opaque base has the characteristics of anthracosis.

Serial bronchograms (Figs. 154, 155, 156 and 157), very clearly show the appearance of the bronchial tree. The expansion of the



Fig 155 Intermediate aspect of filling Ampullar expansions at the end of the bronchus stand out clearly (Cont)



Fig 156 Final filling phase, giving a characteristic picture of this type of ectasis (Cont)



Fig 157 A view of the same case in right transverse position The *iodized oil rosary* is clearly evident, Arrow 1 points to the lower lobe trunk, arrow 2, the middle lobe one; and arrow 3 points out the large incisura that divides these lobes (Cont)

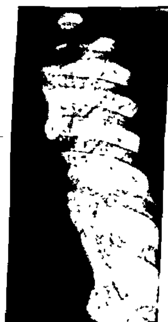


Fig 158 Direct radiogram where instead of opacity in the base, an abnormal transparency is evident (Cont)

branches is scarce, and it would seem that the dominating characteristic is the more or less rhythmic strangulation of the bronchial branch In the more affected areas, the fine ramifications and the foliage are scarce or are absent.

On the left side the process was not so manifest, and we may observe the first stages of this type of ectasis In the direct radiogram (Fig 158), the opacity is not present in the right base but here

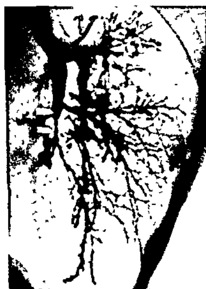


Fig 159 Middle phase of bronchial filling The pathologic condition of the bronchi is evident Note that here also the branch contracts before expanding (Cont)



Fig 160 Final phase The normal foliage Spasm of branches is shown by arrows (End)

we find a more than normal transparency, indicating a moderate emphysema. On this side, the chronic bronchitis process has begun in some branches, especially in the dorsal branches of the lower lobe, but the bronchial tree retains for the most part its normal characteristics, for its calibre decreases towards the peripheral zone, the fine branchings are abundant, and the foliage is formed rapidly (Figs. 159 and 160).

All this indicates anatomical and functional integrity of the bronchopulmonary system.





Fig 155 Intermediate aspect of filling Ampullar expansions at the end of the bronchus *stand out clearly* (*Cont.*)

Fig. 156 Final filling phase, giving a *characteristic picture of this type of ectasis* (Cont)





Fig 158 Direct radiogram where *instead of opacity in the* base, an abnormal transparency *is evident.* (Cont)

branches is scarce, and it would seem that the dominating characteristic is the more or less rhythmic strangulation of the bronchial branch In the more affected areas, the fine ramifications and the foliage are scarce or are absent.

On the left side the process was not so manifest, and we may observe the first stages of this type of ectasis In the direct radiogram (Fig 158), the opacity is not present in the right base but here



Fig 159 Middle phase of bronchial filling The pathologic condition of the bronchi is evident Note that here also the branch contracts before expanding (Cont)



Fig 160 Final phase The normal foliage Spasm of branches is shown by arrows (End)

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All this indicates anatomical and functional integrity of the bronchopulmonary system.

Segmentary Cylindrical Bronchiectasis

In some cases bronchial expansion affects only a few branches. In these cases we are dealing with specific processes and we can *identify* the obstruction responsible for the ectasis. This occurs in bronchial tuberculosis, and is illustrated by the following case.

The patient is a 15 year old girl who was admitted to the Rawson

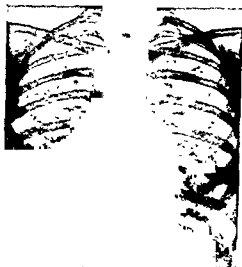


Fig 161 Opacity of the right base and mediastinal extension of the process are evident (Cont)



Fig 162 Initial filling phase showing the expansion of the ventral branch of the lower lobe (Cont)

Hospital in Cordoba. The previous record was as follows: A month previously she had suffered from a severe pain in her side in the right intra-clavicular region, becoming worse on inspiration. Fifteen days later, she had a slight cough and expectorated a small quantity of blood Immediately after the hemorrhage the pain disappeared. She had no fever on admission.

Examination of the chest revealed breathing excursion on the right side, with breath sounds intensified. A few rales were heard. The radiogram (Fig 161) shows the shadow of the right base and the mediastinal involvement.

Laboratory tests were negative for Koch bacilli. The Weimberg-Chedini reaction was negative. A definite diagnosis could not be made, so a bronchial exploration was carried out.

Figs. 162, 163 and 164 show the results of this examination. In Fig 162, representing the initial phase, the normal conformation of the majority of the branches is evident, with the exception of the first ventral branch of the lower lobe which is expanded and is irregular in outline.

Fig. 163 presents the late image of filling in frontal position. It



Fig 163 Late phase showing more clearly the expansion of the branch (Cont)



Fig 164 Transverse view of the affected branch (End)

shows clearly that the process involves only the first ventral branch of the lower lobe.

In Fig 164 (transverse position) affected branch may be identified. In this radiogram we may observe upper branches of the middle lobe, and compare the normal and pathological characteristics of both branches

Later on, Koch bacilli were found in the sputum. Nevertheless examination with iodized oil did not cause any rise in temperature nor did it affect the general health of the patient.

Lobular Bronchiectasis

When it is possible to prove that in a bronchorrheic patient, the ectasis affects only one lobe, particularly the middle lobe, surgery is the indicated treatment. For this reason the radiologic examination must be as thorough as possible, in order to ascertain whether the



FIG 165 Direct radiogram showing a small area of opacity in the projection area of the middle lobe (Cont)

disease is localized or generalized, and whether one lobe only or additional branches also is affected.

The following case demonstrates that surgery should be done early before the process extends and consequently becomes more difficult to cure.

The patient was a woman 36 years of age, who had had chronic bronchitis for many years with periodic exacerbations during which the bronchorrhea and cough increased. In the direct radiogram the projection zone of the middle lobe is slightly darker than the symmetrical zone (Fig. 165).

Bronchography reveals bronchiectasis of the middle lobe only



Fig 166 The image in frontal position Arrow 2 points to the upper inner branch, greatly expanded Arrow 1 points to the other branch in beginning ectasis (Cont)



Fig 167 Transverse position image The branches particularly affected stand out Arrow 1, middle lobe trunk, 2, inner forward branch and 3, the posterior external branch (Cont)

more pronounced in the inner anterior sub-branch, in the other sub-branch, outer lower, ectasis has just begun

Figs 166 and 167 show these changes clearly Arrow 1 points to the outer posterior sub-branch and arrow 2 points to the inner anterior branch

The branches of the lower lobe are *normal*

Dr J M Allende performed a middle lobe lobectomy and the patient recovered

Radiogram 168 shows the appearance of the bronchial tree after the operation, and the bronchial stump.



Fig 168 Bronchogram taken after operation showing the bronchial stump

Bronchiectasis may occur in children as a result of bronchial obstruction from the ingestion of foreign bodies or by segmentary or truncular spasma of the musculature. These types of bronchiectasis are also very frequently observed after whooping-cough, measles or pneumonia. Early intervention is important in children as the surgical possibilities are greater at this age and the patient is cured before the disabling disease has transformed the child into an invalid.

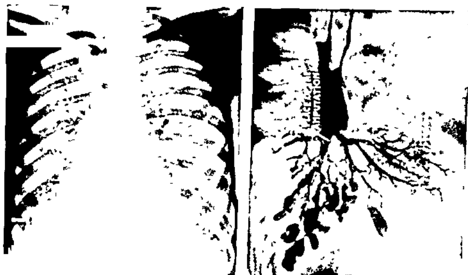


FIG 169 Direct radiogram showing filling of the right cardiodiaphragmatic angle (Cont.)

FIG 170 Bronchogram showing bronchiectasis in the lower right lobe (Cont.)

We have had the opportunity of observing the case of a 12 year old child, who had complained for several years of a post-whooping-cough bronchorrheic process. At the time of observation his general condition was good although he expectorated large quantities of mucus. He had no fever. Direct radiography (Fig. 169), showed an opaque right base especially at the cardiodiaphragmatic angle.

Contrast exploration revealed ampullar and sacciform bronchiectasis in the whole lower lobe field (Fig. 170).

Dr. Goicoechea performed a lobectomy and months later we carried out another bronchial study. The images reproduced in Figs. 171 and 172 were recorded. They show that the branches of the upper

and the middle lobes have expanded, occupying the space left b surgical intervention. The lower amputated bronchus is revealed a a small infundibular stump better seen in transverse position. Bron chopulmonary dynamism has not been altered, nor is bronchiectasi present in the remaining lobes



Fig 171 Postoperative bronchogram showing the displacement of the remaining bronchial tree and the point at which it was amputated (Cont)

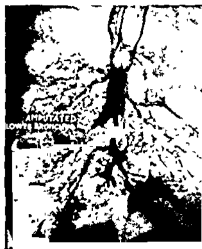


Fig 172 Transverse position bronch gram showing the form and position of th bronchial stump (End)

Bilobular Bronchiectasis

Even though ectasis may begin in a bronchial tree segment as w have just seen, it rarely remains localized there Generally th secretions travel to unaffected areas and thus spread the process

This occurred in the case represented in radiograms (Figs. 173 an 174) The patient, 16 years old, had an acute bronchial process years ago, and has never completely recovered from it. This proces has repeatedly recurred and after each attack, expectoration has bee more abundant During the past year bronchorrhea was continuous

Direct radiograms reveal opacity of the left posterior base. In th right lung an ascending reticulum and a portion of horizonta incisuritis are evident



FIG 173 Frontal position image revealing a left base opacity and a right horizontal incisura tracing (Cont)



FIG 174 Transverse position image, revealing the posterior position on the left base opacity (Cont)



FIG 175 Appearance of the normal foliage in the healthy side (Cont)



FIG 176 Appearance of the bronchial tree in the affected areas Both radiograms (175 and 176) were obtained at the same focal distance (End)

Contrast exploration revealed a bronchiectasis that completely involved the lower left lobe and the linula lobe.

In Figs. 175 and 176 we may compare the healthy bronchial tree on the right side with the affected one on the left side

A left pneumonectomy was performed Pathological examination of the specimen proved that the bronchiectasis affected the lower lobe and lingula lobe only, the latter being pointed out as a third left lobe.

Symmetrical Bilobular Bronchiectasis

Bronchiectasis may occur simultaneously in corresponding areas of both lungs. *Frequently the process involves* both lung bases, less frequently only the middle lobe of one side and the lingula of the other is involved, and it is exceptional to find this process localized in both upper lobes

These multiple localizations necessitate complete exploration of both lungs when surgical intervention is contemplated Otherwise, large lesions, at a distance from the operative field may pass unnoticed.

In one of our patients, we found bronchiectasis affecting the middle and lingula lobes. This 16 year old girl had had frequent attacks of bronchitis with abundant bronchorrhea from childhood In recent years, bronchorrhea had continued intermittently. All therapeutic measures had been unsuccessful

Contrast bronchial exploration brought out the following facts In the right lung there existed a frankly abscessed ectasis of the middle lobe and some bronchographic signs of chronic bronchitis in the branches of the lower lobe.

Fig. 177 reveals evident dynamic and morphologic changes in the trunk and in the branches of the middle lobe. The iodized oil has reached the thick branches of the lower lobe and has become rapidly distributed in the finer branches, while in the middle lobe, the opaque substance has filled a rigid tube lacking all aspiration characteristics For this reason, while in healthy branches only images with an inner outline are obtained, for the iodized oil progresses rapidly within them, in the affected side, images of complete filling are obtained (the outline of the bronchial tube), because all the dynamic characteristics that make the opaque substance progress have disappeared here Fig 178 shows us the same patient in trans-



FIG 177 Frontal view of middle lobe bronchiectasis (Cont)



FIG 178. Middle lobe bronchiectasis, transverse position. (Cont)



FIG 179 Bronchiectasis of the lingula lobe seen in frontal position (Cont)



FIG 180. The same case seen in transverse position (End)

versed position. Here the terminal ectasis of the middle lobe branches stands out.

Contrast exploration of the left lung, revealed a similar process localized in the lingula lobe, that is, in the symmetrical lobe of the middle lobe. As we may see in Figs. 179 and 180; the ectasis causes here the same dynamic and morphologic changes as are noted on the opposite side. Branch suppuration images are also observed in the lower lobe; but in much less degree, and it is probable that they are due to secretions that leaving the lingula lobe fall into the lower one

Bronchography in a Case of Intrabronchial Foreign Body

The presence of a foreign body in the air channel, may cause conditions of the bronchus and parenchyma, that may be confused with infectious processes. If the foreign body is not opaque to roentgen rays this confusion persists and the patient seeks in vain for a cure. Although it may seem strange, foreign bodies are usually taken into the air tube unknown to the patient, sometimes during anesthesia, or perhaps during temporary unconsciousness In the case that we are about to describe, the foreign body, notwithstanding the fact that it was opaque to roentgen rays, was not discovered until after thirteen years of medical treatment The patient was a 45 year old man who consulted Professor Villafañe Lastra for severe bronchitis, which at times was dry and spasmodic; at others coughing was accompanied by slight expectoration The patient had had little sleep for months because of the cough, and had to resort to narcotics. A radiogram taken during the first months of illness (Fig 181) shows an opaque tracing on the tail of the left hilum (indicated by arrows). There is frank emphysema in the region of the costodiaphragmatic sinus (The shadow bordering the chest is the patient's arm)

The peculiar opacity in this chest radiogram, and the emphysema in the base passed by unnoticed by the first doctors who attended the patient, who was submitted to various types of treatment for his chronic bronchitis without receiving any benefit.

Finally he went to Buenos Aires, where he entered a hospital and was treated for more than a year for chronic bronchitis. Several radiograms were then taken A Wassermann reaction proved positive. This finding, together with the patient's clinical appearance led to a diagnosis of luetic bronchitis For several months he received antiluetic treatment without benefit It was true that his appearance

suggested the diagnosis of congenital lues for the root of the nose was flattened, giving it the characteristic *saddle* appearance (Fig 182 and 183). The patient was aware of this opinion for he had been used several times as demonstration for medical students, and he had protested, explaining up to 13 years ago his nose was straight, but the kick of a horse had disfigured it. He said that this accident was



FIG 181 Radiogram taken at the patient's residence several years before we examined him An opacity over the right hilum (see arrow) and one in the right base are seen The lateral shadow on the chest is due to the patient's arm (Cont)

coincidental with the onset of his bronchitis. To strengthen his argument he stated that after the accident numerous bone fragments had been removed from his nose A scar at the root of the nose confirmed the truth of his statement.

Realizing that it was useless to continue these treatments he decided to return to the more favorable climate of Cordoba. After

remaining for some time in the Cordoba hills without any improvement he consulted Professor Villafañe Lastra and five minutes after he had begun to describe his symptoms the distinguished Cordoba physiologist looked at one of his radiograms interrupted the patient, examined him radioscopically and said. "You have a foreign body in your bronchus. That's all." He then immediately requested a radio-



Fig 182 Patient's photograph, frontal view (Cont)

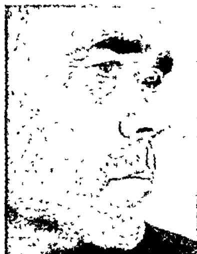


Fig 183 Patient's photograph, in profile (Cont.)

ogic examination, direct and bronchographic, the results of which we shall see now.

Direct radiogram (Fig 184) still shows the opaque tracing, more pronounced in the over-exposed radiogram (Fig 185), but it is not situated nearer the mediastinum and also nearer the diaphragmatic limit, which is due principally to the elevation of the diaphragm

The emphysematous area of the base has become more opaque than that of the opposite side

Bronchography was performed with difficulty for notwithstanding the anesthesia, when the iodized oil entered the main bronchus of the lower and middle lobes, it elicited an intense cough reflex so that the

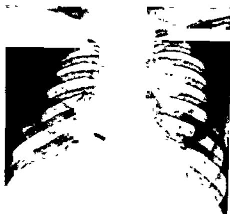


Fig 184 Direct radiogram showing the hidden foreign body in the right heart border line There is no longer emphysema, but ventilation of parenchyma is below normal (Cont)



Fig 185 Radiogram of the area, showing the foreign body on the heart margin (Cont)



Fig 186 Initial phase of bronchial filling showing an obstruction in the bronchial lumen (Cont)

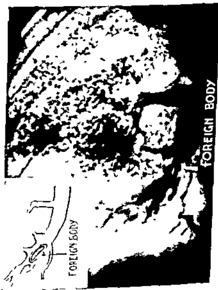


Fig 187 Final phase of bronchial filling, bringing the obstruction and bronchiectasis in the branches into evidence (Cont)

contrast substance was expelled. Nevertheless it was possible to obtain images that revealed the presence of a foreign body in the bronchial channel, as demonstrated in radiograms 186 and 187.

Since the diagnosis of a foreign body on the inner surface of the bronchial lumen was not confirmed, by bronchography, Professor Villafañe Lastra determined to extract it, and asked for a consultation with the bronchoscopist Roger Lanza Castelli Bronchoscopic examination further confirmed the diagnosis for it proved that on the inner surface of the common main trunk of the middle and lower lobes, half way along its course, there was present a ridged reddish elevation The foreign body could not be identified but was undoubtedly included in this granulation tissue. When bronchoscopist tried to touch this surface, the blood that spurted obstructed his vision and therefore also the attempts to extract the foreign body. A second attempt, some days later, also result in failure It was then decided to extract the foreign body under radioscopic vision by means of the bronchoscopic forceps being guided by the opacity indicating the foreign body After a few attempts he succeeded in extracting the foreign body which proved to be a bone having the characteristics of the *vomer*, as may be observed in profile and front view in Fig. 188

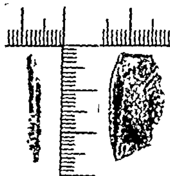


Fig 188 The foreign body extracted, seen from a front and a side view

The clinical picture changed instantly. The cough disappeared the day the foreign body was extracted A bronchographic exploration one month later brought the change in the bronchial picture into evidence. As Figs. 189 and 190 reveal, an expansion of the bronchial branches had occurred in the area of the lower lobe The bronchial lumen was reduced at the place where the foreign body had been imbedded.

This bronchial expansion demonstrates the profound changes that may occur in the bronchus even from indirect causes and explains the possibilities of gross changes in the bronchial conformation, due to acquired processes and not to agenesia.



FIG 189 Bronchial exploration one month after the foreign body was removed, showing the bronchial expansion of the branches of the lower lobe and the strangulation of the lumen in the area where the foreign body was embedded (Cont)



FIG 190 Picture obtained three months after the foreign body was removed Note persistence of the bronchial expansion

Bronchial Exploration in Lung Actinomycosis

Actinomycosis localized in the lung parenchyma does not produce a characteristic bronchographic image, and it may be confused with those produced by other benign pleuropulmonary or malignant processes.

The following case illustrates the behavior of the bronchial tree when actinomycosis is localized in the cortical region affecting the pleura particularly. The patient, a 35 year old man, was admitted to Rawson Hospital on the Service of Dr. Villafañe Lastra. During the three months before admission he lost 10 Kilos in weight; complained of a pain in the right chest and purulent bloody expectoration. He had had only slight fever. For more than three months he had had an abscess in the left side of the neck, for which he had undergone two operations. This lesion had the characteristics of cervicofacial actinomycosis.

The direct radiogram (Fig. 191) shows an opacity in the base and the outer third of the right lung, having indefinite outlines and irregular density.

After this radiogram was made a soft tumor was observed on the affected side in anterior third of fifth intercostal space

The tumor was incised and microscopic examination confirmed the presence of actinomycosis.



Fig 191. Direct radiogram showing an opacity of the right base, having indefinite outline and irregular density. (Cont. in Fig 192)



Fig. 192 Initiation phase of bronchial filling, showing signs of suppuration in the branches of the middle lobe and obstruction of the fine branches (Cont in Fig 193)

Based on the belief that iodized oil would not only better reveal the pathologic process, but would also have a local or general therapeutic effect, it was decided to perform a contract exploration.

The opaque medium brought out two types of images, a) *The bronchial displacement* due to the pleural process, and, b) the obstruction of small branches near the lesion

In Fig 192 we see the bronchus in the initial phase of filling, and in it signs of abscess of the middle lobe branches and the obstruction of medium sized and fine branches

The succeeding filling phases further revealed the purulent contents of the branches, as well as the sudden obstruction suffered by

the finer branches on nearing the pleuropulmonary affected zone (Fig. 193).

In the final phase, the images already described were confirmed as well as the pressure on the branchings corresponding to those of the lower lobe (Fig. 194).

From our bronchographic study concluded that the actinomycotic



Fig 193 Intermediate phase of filling, where the signs of suppuration and obstruction of the fine branches are confirmed and the repulsing becomes evident (Cont.)



Fig 194 Final phase of filling, confirming the signs of suppuration in the middle lobe branches and repulsing of the lower lobe branches

cortico-pleural process had originated *in the middle lobe branches.*

The iodized oil that remained in the acini, was utilized for radiologic therapy, for on irradiating this area, the secondary rays had a therapeutic influence.

CHAPTER X

Bronchial Exploration in Emphysema and in Asthma

In our study of bronchopulmonary diseases up to this point, the information gained from exploration of the bronchial tree by means of contrast, medium has brought out principally changes in *calibre, conformation* and *distribution*, that is, *morphologic alterations* in the branchings.

There are other diseases in which contrast exploration, brings into evidence, not only slight morphologic changes, but also the predominant changes in dynamism. Among these diseases, those which present the most varied aspects are *emphysema* and *asthma*

These changes in dynamism are clearly evident on the fluoroscopic screen. It is shown that the opaque substance is *not sucked in* by the fine branchings during respiration, remaining mostly in the medium sized and large bronchi. Furthermore, the opaque substance, instead of forming transient and changeable images, as is normal, has a tendency to form *constant images*.

In these diseases, the graphic record on a radiographic film give a very poor idea of what is really happening in the bronchi Because of this fact, and in order to establish this pathology, it is necessary to obtain a serial record from the moment the contrast substance is introduced until a few minutes have passed This serial record provides accurate information as to the phenomena that occur in the bronchial system in these diseases, and it records especially the slight mutability of the images, for those obtained in the initial phase of filling are very similar to those registered later, once the introduction of the opaque substance has been completed

In these diseases, the abnormalities in the *larger branches* as well as in the *foliage* are particularly evident. The calibre of the secondary branches is manifestly *smaller than normal*, indicating a spasm whi
reduces their lumen and dynamism. The ow [illegible] re
however, the normal c [illegible] *istic of* [illegible] gre
toward the periphery. T [illegible] of the b [illegible] u
only in the incipient sta [illegible] proce[illegible] [illegible] g

the opaque column becomes irregular. We then see it interrupted suddenly in the medium calibre branches, as if it had encountered an obstruction in the bronchial lumen. This is because the opaque substance is compressing the column of air in the bronchiole, like a piston; and the lack of normal motility in the bronchial tube together with the lack of thoraco-alveolar aspiration causes the column of air to remain static thus slowing the progress of the contrast substance.

The *foliage*, scarce in some regions, is completely absent in others. There is no uniform distribution of this foliage, due in part to anatomical changes in the lung, and in part to the absence of the factor of dynamism which would facilitate the progression of the opaque medium toward the acini.

All these graphic expressions of the pathology of broncho-alveolar dynamism combine in varying degrees in diseases having different anatomo-pathologic substrata, resulting in mixed bronchographic pictures, some of which indicate alterations in bronchial morphology *and others that reveal only changes in dynamism.*

The same disease may go through evolutionary stages showing at first only alterations in dynamism, and toward the end are characterized by changes that are predominantly morphologic.

Contrast exploration does not discover the cause of the emphysema, *that is the obstruction of the bronchial lumen responsible* for the increase in alveolar pressure on expiration, but it permits an analysis of the indirect signs that lead to diagnosis. In these cases it is necessary to obtain radiograms on forced *inspiration* and *expiration* so that images may provide the maximum information.

Emphysema of Small and Numerous Vesicles

In the bronchographic pictures of emphysema that we shall now consider, varying features are observed according to the evolutionary stage of the disease at which the pictures were obtained. We shall present intermediate pictures between the initial and the final stages.

In emphysema the functional alteration is predominant or may even be the only change noted at the initiation of the process. Little by little, however, anatomic lesions are added, occurring mainly in the acini and surrounding tissues. These evolutionary changes are not simultaneous in the whole lung, and it is for this reason that we may be surprised by the three schematic features of emphysema in the same case namely, *initiation*, being predominantly functional;

quiescent, with a combination of the anatomic and functional pictures, and *final*, where the anatomic lesions predominate.

Let us consider some of these cases.

Serial bronchograms 195, 196, 197, 198 and 199 represent a patient having a radiographic picture of a moderate right base emphysema that was slightly evident in the direct radiogram as well as on clinical examination. Certain areas of the lower lobe are more affected by



FIG 195 Initial phase of filling, showing the fine calibre of the principal branches and the lack of secondary branchings in the costo-diaphragmatic angle (Cont)



FIG 196 Subsequent image confirming absence of fine branchings in the costo-diaphragmatic angle area and base (Cont)

the process, and the radiologic signs are more characteristic. In general the bronchial tree has a more than normally reduced lumen and the filling is not uniform throughout, for while in some areas the opaque substance has reached the fine ramifications, in others it still remains in the thick and medium sized trunks. At the moment that the foliage is formed, the contrast between the normal and the diseased areas becomes intensified While in the healthy area the opaque substance rapidly forms normal foliage, in the diseased areas fine branchings are traced, but no foliage

Progress from the initial phase to the final phase of bronchial

filling, is slow so that we have had the opportunity of obtaining a complete serial record of what has happened in the bronchus.

This bronchographic picture may have been suspected in some cases in the direct radiogram, when the emphysematous areas are evident, when the direct radiogram shows no changes in the normal image, notwithstanding the existence of a marked broncho-alveolar functional alteration, bronchography brings into evidence great deviations in dynamism and morphology.



Fig 197 Foliage begins to form, clearly showing the emphysematous areas (Cont)



Fig 198 Foliage has formed in nearly the whole of the explored area, but in one portion we see only some fine branchings without foliage (Cont)

In other cases direct radiography leads us to the diagnosis of a disease of the bronchial type, such as cystic bronchiectasis, and it is only by contrast exploration that we find the process is not of bronchial origin but originates in the acini or in the alveoli, that is, it is really a case of emphysema with large bubbles.

An illustrative case is represented in radiogram 200. This patient was an adult presenting the clinical picture of asthma that at times was bronchorrheic. Radiography shows a lung base darker than normal, and in it annular images of varied sizes and fine outlines. There are no levels seen within these rings.

Fig 199 Terminal image of bronchial filling, revealing areas that are definitely devoid of foliage (End)



Contrast exploration revealed diminishing of the bronchial calibre, the slow appearance of the fine branchings and irregularity in foliage formation. No bronchial fermination communicated with the rings observed in the direct radiogram, thus confirming the diagnosis of emphysema.

Fig. 201 corresponds to the initial phase of bronchial filling of the main arborization. Thin



Fig 200 Direct radiogram showing multiple annular shadows in the right lung base (Cont)



Fig 201 Initial filling phase Well filled principal branches having no secondary branches, stand out The pre-incisural branch of the middle lobe is arched, showing the displacement due to emphysema (see arrow) (Cont)

branches are observed not having very smooth outlines, and although these branches are filled up to the terminations, the normal picture of secondary branchings is not in evidence. This indicates a functional delay in aspiration.

Our attention is called to the fact that the pre-incisural branch of the middle lobe forms an arch having an inward bending, thus re-



Fig. 202. Secondary branches begin to appear. The middle lobe branch is still arched (indicated by arrows) (Cont.)



Fig. 203 The foliage has begun to form but in irregular fashion. There is no expansion of bronchial branches nor cystic bronchiectasis (Cont.)

vealing a displacement, possibly caused by a deformity of the lobe due to emphysema.

Thinner branches are noted in the radiogram, but the pre-acini fine branchings are not yet evident. The middle lobe branch still retains its deformity.

In radiograms 202 and 203 the final branching begins to appear and the foliage formation is begun. It is now evident that the distribution of this foliage is irregular. No expanded bronchial termination nor cystic bronchiectasis is yet evident, as the direct radiogram led us to suppose.

Radiograms 204 and 205 show the foliage formed. Areas in which

there is a scarcity or complete absence of foliage are evident.

No bronchial branching ends in a bubble and in those in which the direct radiograms show annular images, instead of finding a small pool of iodized oil, we find a transparent area with complete absence of the opaque substance.



Fig 204 The foliage phase has been completed but there are some areas in which it is absent (Cont)



Fig 205 The bronchial filling being completed, areas are seen where the foliage is dense and others where it is scarce In the region of suspected bronchiectasis, there are areas devoid of foliage, indicating emphysema (End)

The Large Emphysema Vesicles

The large emphysema vesicles appear in the direct radiogram as a finely traced ring, which is sometimes barely perceptible and may be completely or only partially traced If the lung parenchyma that the ray has to penetrate is thin the vesicle stands out as a transparent circle having no lung reticulum, or containing the normal reticulum, if the parenchyma is very thick *images taken from different angles* are necessary to reveal the *extension* and *true form* of the vesicle These radiologic characteristics refer to the vesicle that has not suffered inflammatory processes, for those that have been subjected

to infectious processes acquire a thicker and more irregular outline and cause confusion within the differential diagnosis of air cysts and hydatid residual cavities.

For these reasons, direct radiography is insufficient for a correct diagnosis of this lung disease. It is necessary to resort to *tomography and especially to contrast exploration of the bronchus* in order to obtain conclusive data that may define the anatomic substratum of the process.

In the tomogram, the absence of reticulum in the plane and in the area circumscribed by the finely outlined ring, is evident. In addition to this ring, we see the vessels displaced by the eccentric growth of the great vesicle.

The contrast method brings out very interesting information as to whether an annular image in the lung field is caused by an emphysema vesicle or by some other pathologic factor.

The radiologic characteristics present variations, according to whether we are dealing with *small, large* or *gigantic* vesicles. Their number also is a factor, for when they are single they are easily identified, while *multiple* vesicles can be recognized only as a mass.

In the case of a medium sized vesicle the changes in number and calibre of the bronchial branches are minimum or absent, nor does the bronchial displacement become clearly evident. The penetration of the opaque substance into the vesicle is exceptional, and if obtained, is very slight. This is due to the fact that the vesicle communicates with the exterior through a minimum calibre bronchus, the respiratory bronchiole, the dimensions of which preclude the passage of substances having a high viscosity, like iodized oil.

On the other hand, this narrow duct, playing the role of a valve, allows air to penetrate the acini easily, but causes difficulty in leaving, resulting in the expansion of the alveoli and the formation of the vesicle.

The large vesicles cause the bronchial displacements already mentioned; but the calibre and number, as well as the characteristics of the branchings always remain normal. When the vesicle has been the site of an inflammatory process, it loses its fine outline, as we have said, and the bronchial communication becomes wider. This may cause confusion if the other bronchographic signs are not given their due attention

In the case of an air cyst, both the calibre and the branchings

are considerably modified, especially as to the scarcity of second[illegible] and fine branchings, and irregularity in the formation of the folia[illegible]. In both instances iodized oil penetrates with difficulty; but t[illegible] changes in the branches and in the foliage are characteristic on[illegible] of the air cyst.

In the case of a residual cavity of a hydatid cyst, the followin[illegible] bronchographic signs are found: Ample communication of the bronchus with the cavity, neighbouring bronchial expansions and few or no modifications in the number of secondary ramifications.

Of great significance are the variations in the size of the air cyst during respiration while the size of the large emphysema vesicle remains unchanged.

The air cyst is similar anatomically to the bronchus, and communicates with the outside. It can therefore undergo expansion and reduction like the normal bronchus, for the cyst itself constitutes a gigantic bronchus. On the other hand, the connective tissue wall of the other cavities lacks the elasticity of the bronchial wall (for example, the residual cavities of the hydatid cysts) or possess a valvular communication with the exterior, and therefore their dimensions are not reduced during expiration (for example, the large emphysema vesicles).

This is not a pathognomonic sign but constitutes one more factor within the differential syndrome of the cavities of congenital and acquired origin

The *gigantic emphysema vesicle* presents a very characteristic radiographic picture and only seldom is it confused with cystic pneumothorax.

The direct radiogram shows the extraordinary transparency of the lung field. In the affected area no reticulum whatever is seen, the only evidence being a few lineal tracings that correspond to the incisura or to sclerotic cords.

As these gigantic vesicles always develop with a generally abnormal state of elasticity and dynamism, the enormous vesicle is always accompanied by others of smaller size, which contribute to the total disfiguration of the lung radiogram.

Bronchography provides unmistakable radiologic evidence of the displacement of the bronchial branches, while their reduced calibre and the almost complete absence of foliage confirm the diagnosis.

We wish now to emphasize the radiologic characteristics of the

various aspects of the large vesicle emphysema, as demonstrated in *the following cases of small and medium sized vesicle emphysema.*

Case of a Medium Sized Vesicle

The patient was 23 years old. There was no history of previous lung disease until two months previously when he begun to complain



FIG 206 In the center of the lung field, an annular image very finely traced may be seen (Cont)



FIG 207 Intermediate phase of bronchial filling, where the normal characteristics of the branching become evident as well as *the small quantity of contrast substance* within the vesicle (Cont)

of a slight cough and expectoration of a slight amount of blood on one occasion. No Koch bacilli were found in the sputum. Casoni and Weinberg reactions were negative. There was fever.

The direct frontal radiogram (Fig. 206) shows an annular image *in the centre of the lung field, having* a very thin tracing, and irregular ovoid form. Bronchography proved that no alterations in calibre or in number existed, nor was the distribution of branches in

the vicinity of annular images altered. The penetration of the opaque substance was very slight, as bronchograms 207, 208 and 209 reveal.

Foliage was absent in small areas neighbouring the annular image proving the presence of a localized emphysema. The history and x-ray reports reveal the presence of an emphysematous area having med-



[illegible]



Fig 209 Late filling phase, revealing three half moon images corresponding to the bottom of three vesicles containing the residue of the contrast substance (End)

ium sized vesicles, one of which is clearly evident on account of its predominant size.

Case of a Large Vesicle

The patient was a 30 year old woman, who consulted Dr. Raul Ortiz, because of slight pain in the right chest, becoming severe on deep inspiration. There was no cough, fever, nor history of any serious lung disease.

The radiogram (Fig 210) shows an annular image situated in the middle field and outer area of the right chest The tracing of this ring

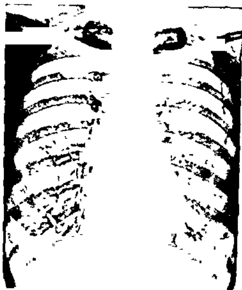


Fig 210 Front view showing a finely traced oval shaped ring in the right lung (Cont)



Fig 211. View of the same case, in transverse position, showing a finely traced circumference of mathematical regularity (Cont)



Fig 212 Tomography in the equatorial plane of the emphysematous vesicle revealing the vascular displacement caused by the emphysematous globe (Cont)



Fig 213 Initial filling phase, revealing the repulsing of the principal branches and the interruption of the opaque substance near the borderline of the vesicle (Cont)

is very fine and its outline is gradually lost at the rib border Within there are very slight traces of elements of the lung reticulum

Transverse position radiography allows us to see the whole ring, as if it were a perfect circumference traced with a fine point (Fig 211).

Tomographic study confirmed the absence of the reticulum in the



Fig 214 Intermediate filling stage, showing secondary and fine branching of normal type (Cont)



Fig 215 Final filling stage, clearly showing normal foliage, although it is repulsed toward the middle line There is no contrast substance in the vesicle (Cont)

interior of the ring and revealed the displacement of lung vessels in the proximity of the inner portion of the outline (Fig 212)

However, it remained for bronchography to provide the conclusive data that confirmed the emphysematous nature of the process. The introduction of the opaque substance immediately revealed unmistakable images of pressure on the branches, caused by the expansion of the large vesicle, and explained the mechanical difficulties it had caused in the neighboring branchings (Fig 213).

The intermediate phase of bronchial filling revealed secondary

and fine branching normal in number and in conformation; the final filling phase showed foliage of normal type, lacking only in the area corresponding to the large vesicle and in part also in the area underneath it (Fig. 214 and 215). The opaque substance has not penetrated the vesicle. In the transverse position, in this final filling



Fig 216 Transverse position radiogram No changes in the foliage are seen The vesicle cannot be distinguished (Cont)



Fig 217. Appearance of the vesicle after pneumothorax. It is evident that the unequal intra-thoracic pressure has not been able to flatten the vesicle on account of the *bronchial valve*

phase, the only abnormality observed is the pressure of the vesicle upon the central zone, but in all these areas filled with iodized oil, the foliage is of the normal type (Fig. 216). No contrast substance is observed within the vesicle.

With the object of determining the superficial situation of this great vesicle, a pneumothorax was carried out (Fig. 217), which

revealed the great emphysematous dilatation extending beyond the limits of the lower collapsed lobe.

Gigantic Apex Vesicle

The patient was a 20 year old man whose history revealed no evidence of a lung disease During a physical examination when he was drafted into the army a roentgenogram revealed a large cavitary image, occupying the whole left lung apex.

In the direct radiogram (Fig. 218) this cavitary image is seen to have a liquid content that forms a level and has a very distinct outline No other abnormalities are observed in either lung The only pertinent finding in the history was that whenever the patient had a cold, he expectorated yellow viscous mucus. No Koch bacilli were found in the sputum



Fig 218 Direct radiogram showing the characteristics of the cavity in the left apex Within this cavity there is liquid, the level of which may be seen Right lung completely normal

In view of this radiologic and clinical picture we needed bronchial exploration to decide the diagnosis Should a con-enital malformation prove to be present, he iodized oil would encounter serious fficulty in penetrating the cavity, for, as have said, the air cyst or the emphy-na vesicle communicates with the nchus only through a very narrow ning. On the other hand, if a destruc- lung process was being eliminated ugh the bronchus, the cavity in gen- would communicate amply with the le. The bronchogram (Fig 219) in teral decubitus, showed that the cavity communicated with the ius through a narrow channel

cond radiogram (Fig 220) taken immediately after the first, d that the difficulties in penetration encountered by the substance were not accidental, for notwithstanding the fact ufficient period of time had been allowed for the iodized oil

to trickle through the bronchus and penetrate the cavity, only a small quantity was seen within it.

On observation it is evident that, in addition to the great cavitary image, medium sized and fine well formed bronchi exist, though they are subjected to pressure by the eccentric expansive growth of the



Fig 219 Bronchography showing the difficulty encountered by the opaque substance in penetrating the cavity. Neighboring bronchi are normal. (Cont)



Fig 220. Second bronchogram of the same case showing that the difficulty encountered by the opaque substance in penetrating the cavity was persistent.

pathologic process. In the vicinity of this disease process there is normal foliage, a phenomenon that never occurs near the air cyst. Only a gigantic emphysema vesicle can produce a bronchographic picture with these characteristics.

Giant Emphysema

Large emphysema vesicles may be single or multiple, and as we have pointed out previously they can be the cause of diagnostic errors if the case is insufficiently studied In some clear cut cases, however, direct radiography is sufficient for diagnosis, and tomography and bronchography merely confirms the diagnosis.

Case 1: This was true in the case of the patient whose radiogram we present in Figs. 221, 222, 223. Direct radiography shows a transparency in the right base with an opacity surrounding it above. The outer limit of this clear transparency is also evident. Bronchographic study proved that a great multilobular emphysematous vesicle had caused upward displacement of the parenchyma. The position of the obstruction could not be determined due to the great displacement of the bronchial tree.

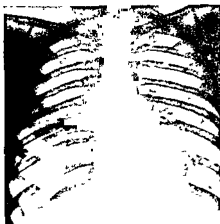


Fig 221 Direct image revealing the transparency of the right base and traces limited to the outside (Cont)

Case 2: This patient was a 50 year old man, with progressively severe lung and heart complaints. He was admitted to the hospital during a severe cardiovascular crisis and complete bronchial exploration had to be delayed for 20 days



Fig 222 Bronchogram showing that great upward displacement of the bronchial tree due to the growth of the vesicle (Cont)



Fig 223 Transverse position image showing the displacement and dislocation of the branches (End)

Radiogram 224 shows the appearance of the lung field. The extraordinary transparency of the upper areas of the chest, especially on the right side, is evident. In these regions the lung reticulum is absent. The lower regions are more opaque than usual and the normal tracing is replaced by thicker and more irregular tracings. In the right base there is a fluid level.



Fig 224 Front view radiogram revealing the abnormal transparency of the upper fields, the intense opacity of the bases, and the level in the right base (Cont)



Fig 225. Transverse position radiogram showing the upper and forward position of the transparency and also the anterior location of the liquid Some tracings furrowing the transparency are also seen. (Cont)

In transverse position (Fig. 225), it is evident that the area of lung transparency completely fills the anterior chest and the upper half of the posterior region. Only the lower and posterior regions contain collapsed lung parenchyma. The transparent areas by some tracings are of different thickness. The liquid seen in the frontal radiogram in this instance occupies the bottom of the large air sac situated in the anterior region of the chest.

Bronchography was carried out without accident, notwithstanding the difficulty of hematosis. Fig. 226 and 227 represent consecutive pictures of the bronchial tree, showing that the normal

characteristics have disappeared completely. The principal branches are repulsed toward the lung base, they no longer open out fan-wise, in the normal manner, branches tend to be parallel to each other as the branches of a tree blown by the wind. Their calibre is smaller than normal, although it has the normal characteristic of decreasing



Fig 226 Initial filling stage in the previous case The branches are displaced downward, are parallel to one another, and have a calibre greater than normal, with scarcity of fine branchings and incomplete filling (Cont)



Fig 227 Intermediate filling stage, where the lack of fine branchings and foliage may be noted in addition to that shown in previous figure (End)

toward the periphery The number of secondary branches is approximately normal, but the fine branches are fewer

Foliage is scarce or does not exist, for neither the dynamic state nor the calibre of the fine branchings in this case favors the penetration of the opaque substance into the acini.

Filling is not uniform for the secretions and bubbles of gas interrupt the continuity of filling with the contrast substance.

The distinction between a large emphysema vesicle occurring with hypertensive crisis and valvular pneumothorax has an importance not only in treatment of the disease, but also in relation to prognosis.

This distinction offers no difficulties when the vesicle is of medium size for it is then possible to see, in the direct radiogram, the very characteristic valvular displacements that we have had occasion to point out in preceding paragraphs. When, on the other hand, the vesicle has expanded so much that its walls are in contact with the chest walls, it is necessary to resort to other means of exploration to differentiate it from hypertensive valvular pneumothorax.



Fig 228 Direct radiogram showing transparency of the entire right chest with a liquid level at the base (Cont)

One of these methods is bronchography, which can be carried out only in a few cases on account of respiratory difficulty caused by the disease. In these cases great caution is advisable. Only small quantities of the opaque medium should be introduced and complete anesthesia must be obtained so that the coughing efforts do not increase the pressure of the vesicle or of the pneumothorax.

Under these conditions we had occasion to explore a patient who had consulted Professor Villafañe Lastra for pain in the right chest, with dyspnea, and slight cough but no fever. The disease subsided spontaneously and dyspnea occurred only on exertion. The direct radiogram shows a complete transparency in the right lung field with an opacity in the lowest portion of the right chest and forming a level although it has an irregular outline (Fig. 228). Contrast exploration was effected without difficulty, and 10 cc. of iodized oil were introduced, revealing almost complete collapse of the right lung. There were no branch displacements that would lead to the expectation of finding a gigantic emphysema vesicle Fig. 229 shows the appearance of the bronchial tree seen in frontal position and Fig. 230 a view in an incomplete right transverse position. In these bronchograms we observe that the main bronchus and the principal bronchi, the only

ones visible, are reduced in size, are grouped one against the ot and have lost their normal dynamism, for the opaque medium not absorbed. Contrast exploration did not permit the discovery the broncho-valvular communicating orifice. This is a common currence, for this orifice occupies the most superficial areas of lung which media having a great viscosity do not reach.



FIG 229 Bronchogram in frontal position The displacement of the right bronchial tree may be observed (Cont)



FIG. 230 Transverse position bronchogram (End)

Bronchoscopic examination in this patient showed repulsion the bronchial branches and a hernia of the main upper lobe tr within the main right bronchus These characteristics and bronchial dynamics observed during endoscopy confirmed the di nosis of giant vesicle emphysema, and not a pneumothorax as direct radiologic image had led us to suspect.

Emphysema and Bronchiectasis

In clinical dyspnea, anatomo-pulmonary pictures of the m diverse types are found.

In some patients only small or large, single or multiple vesic are observed causing respiratory difficulty; in others we find c

physematous processes associated with bronchiectasis with or without bronchorrhea, and in another group of patients a general or segmentary spasmodic state of the bronchial tree stands out, causing respiratory difficulty due as much to the reduction in the calibre that reduces the volume of air inspired each minute as to the difficulty in the explusion of the residual air.

These distinctions may be determined in some cases by direct radiography and by clinical examination but contrast study of the bronchus *is always necessary because it shows not only the presence* of the disease but also its extension and association with other processes such as ectasis.

Regarding the first group, that is, the purely emphysematous picture we have spoken of in preceding pages we shall now point out the bronchographic aspects presented by bronchiectasis associated with emphysema. The third group, the asthmatic picture existing along or associated with other diseases, will be considered in a separate chapter.

As we have pointed out in detail in the previous chapter, the expiration obstruction causes the expansion of the peripheral broncho-alveolar sector. The mechanical or functional cause of this obstruction alone provokes alveolar ectasis when the obstacle is situated in the terminal bronchus and broncho-alveolar ectasis when it is situated in the larger bronchi. In the latter case the picture of ectasis becomes manifest first in the alveolar tissue but finally appears in the bronchi.

For this reason we find pictures in which emphysema images are confused with those of bronchiectasis, as occurred in the following cases.

A typical picture is that of a patient (Fig. 231) who had suffered for several years from asthma with dyspneic crises. In the direct radiogram an intense emphysema is observed in the left base and a *large emphysema vesicle in the retrocardiac region.* Contrast exploration showed a mixed picture of the bronchial tree. The spasmodic branches alternated with the expanded ones and the pointed *terminations alternated with those undergoing* ectasis. As may be seen, Figs. 232 and 233, the bronchographic picture indicates the presence of multiple bronchial obstructions that have provoked *the formation of emphysema and of* bronchiectasis. The scarcity

of fine branchings and foliage is due principally to the spasmodic state responsible for reducing the bronchial lumen and making thoraco-alveolar aspiration difficult, an impediment to the filling with iodized oil.

Another illustration is the case of a young patient who had had a severe lung disease and who later came to us complaining of dyspnea, cough and expectoration. There was an accompanying left pleurisy Direct radiography showed left lung emphysema with numerous thick tracings in the same lung



FIG 231 Direct radiogram showing a frank emphysema of the left base (Cont)



FIG 232 Bronchogram showing fine branchings without foliage having some ampullar and some cylindrical ectasis (Cont)



FIG 233 Bronchogram showing the presence of functional and anatomical bronchial obstructions that cause ectasis and emphysema (End)

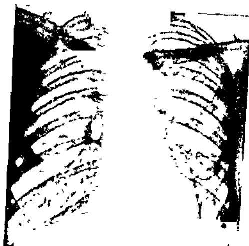


FIG 234 Direct radiogram of a left lung emphysema showing liquid level (Cont)



FIG 235 Bronchogram showing large emphysema vesicles repelling the branches of the upper lobe and bronchiectasis surrounding the emphysema vesicles (End)



FIG 236 Right chest showing extensive lower lobe emphysema. (Cont)

field and a low liquid level (Fig. 234). Contrast exploration showed the presence of large emphysematous bubbles in the upper field with bronchiectasis in the entire area. There also existed emphysema without bronchiectasis in the middle field and other large vesicles next to the base (Fig. 235).

Radiogram 236 represents an adult patient with clinical picture of asthma, and radiologically, that of a lower lobe emphysema. In the direct radiogram there was nothing to lead to the suspicion that in addition to the emphysema there was present another lung disease process.

Radiogram 237 shows the appearance of the bronchus at the initial stage of fill-

ing. The calibre of the branches is larger than normal and does not decrease toward the periphery. The outline is festooned instead of being smooth, and the poverty of fine branching is manifest, especially at the base and in the pericardiac region. Radiogram 238 shows a similar picture although it was obtained one minute later.



FIG 237 Initial filling stage Expanded bronchi, scarcity of secondary branches and lack of foliage are evident (Cont)



FIG 238 Final filling phase, confirming the absence of secondary branching and the presence of an abnormally constituted and distributed foliage (End)

The foliage begins to form but its distribution is irregular and dense instead of the normal fine granulation.

Emphysema and Fibrosis

When emphysema accompanies fibrosis, direct radiography may present an erroneous picture for cavities may be simulated that are in reality only emphysematous vesicles surrounded by sclerotic tissue. In these cases of many old asthmatic patients having bronchorrheic incidents and a history of repeated lung disease bronchog-

raphy illustrates well the anatomic conditions of the lung and reveals the cavities if they really existed, or brings into evidence the emphysematous vesicles that simulate lung ulcerations.

Before deciding on contrast exploration, it is necessary to ascertain whether the pathologic process is of a bacillary nature, for in this case, bronchography with iodized oil is contraindicated. For these patients other opaque substances may be utilized, such as Uroselectan or Perabrodil, which have a more stable iodine molecule and a much more rapid elimination time.



FIG 239 Direct radiogram of chest of a patient with chronic asthma, showing emphysema, fibrosis, and ulceration of the lung (Cont)

A case with this type of pathology, is that of a patient whose radiogram is shown in Fig. 239. The patient was a chronic asthmatic having congestion and expectoration that varied in quantity and quality. Koch bacilli had never been found in the sputum. Contrast exploration of the bronchus revealed the extensive disorganization of the airways, as much bronchial as alveolar. The larger bronchial branches have been displaced from their normal position, the calibre is irregular and the bronchial branches zigzag through the lung field. The number of branchings is approximately normal, but their mutual relationship is capricious.

The foliage begins to form and stops a moment later, as may be seen in radiogram 240 and 241. The foliage is also strange, for it becomes grouped in some regions and is absent in others; while in one place it is formed by a fine granulation in others it is formed by thick grains that seem to be micro-cavities. Fibrosis and emphysema have caused this strange picture, where everything is found but the cavities suspected in the direct radiogram.

Bronchography in Asthmatic Patients

The bronchographic study of asthmatic patients is very revealing, for it clears up many aspects of the pathogenesis of this syndrome and emphasizes the exceptional importance of dynamic and tonic

the bronchi in broncho-pulmonary pathology.
ıchograms of asthmatic patients these principal facts

ıdent reduction in the calibre of the bronchial branches



ıhogram that reveals the
ıization of the broncho-
(Cont)



FIG 241 Late picture of exploration, where the irregular distribution of the foliage is evident (End)

ird and fourth order in *one segment or zone*, of the lung
: *whole lung.*

ısence of fine branching particularly of the *terminal*
his affected lung segment.

:k of foliage in this area, as a result of the impermea-
erminal bronchiole to the contrast substance.

tensified delay in the progression of the iodized oil in
egment, where it remains for a considerable time with-
ınated or without being aspirated by the fine branching
esence of numerous *gas bubbles and mucus patterns* that
progression of the contrast substance.

6). The nearly complete *loss of movement* of the bronchial tree *during respiration*, in the affected area, due in part to the spasmodic rigidity of the branches, and in part, to the inadequate expansion of the diaphragm.

7). The fact that the *bronchial calibre in the affected zone under*goes no expansion during inspiration and no reduction during expiration.



Fig 242 Characteristic and unmistakable picture of an attack of asthma While foliage forms in one area, in the other the contrast substance remains in the large and medium sized bronchi These bronchi have been reduced in their calibre and are subject to frequent strangulations

All these characteristics confirm beyond a doubt the area or lung segment in the grip of asthma, and, as Cruciani and Noguera have accurately proved it is strange that after so many years of contrast study of the bronchus, these characteristics have passed unnoticed.

The bronchographic observations mentioned above are demonstrated in the following cases:

Case 1. The patient was a nine year age of four he had suffered from irritability of the respiratory tract, especially the bronchi, and had had attacks of asthma Medical treatment of various types failed to bring relief and the child was admitted to the pediatric service of the "Hospital de Ninos" in Cordoba.

Examination by Dr. J. M. Valdes brought out the following *findings:* the boy was pale and undernourished. Asthmatic condition and a slight rhonchus was heard in both lungs There was no fever. Sputum examination revealed no Koch bacilli and the Mantoux intradermal reaction was negative

In direct radiography, only a badly distributed reticulum in the region of the base and right lung field were evident. Nevertheless there were no frank areas of emphysema or characteristic infiltration. Contrast exploration of the bronchus was carried out the first time during a severe attack

and the result of this examination may be seen in Fig 242 In it three features not usual in contrast exploration stand out *While the apical zone is in the typical foliage stage the contrast substance has not penetrated the rest of the lung.*

In the upper lobe itself only the apical branch is permeable whereas the *axillary* and *anterior* branches have allowed a small quantity of the opaque substance to penetrate, without reaching the fine branches

The branches of the middle lobe have not become opaque and only a small portion of the main trunk is seen. In the lower lobe, three thin strangulated branches may be observed among which a little foliage is seen The opaque substance has not been insufficient, for it fills all the lower common bronchus

These three features of contrast exploration, namely, *area with foliage*, *area impermeable* to the opaque substance, and *branch spasm*, demonstrate very clearly the picture of asthma

There is an area in which the iodized oil encounters an obstruction due to the fact that the bronchial trunks of this area are undergoing an intense spasm and are physiologically *strangulated* at the place where they originate. In order to explain this strangulation, we repeat in Fig 243 what we have already considered in the chapter referring to bronchial anatomy This figure calls to mind the disposition of the smooth muscular fibres at the site of origination of a secondary trunk and helps us to understand how the contraction of these muscular fibres may almost completely obstruct a bronchial branch.

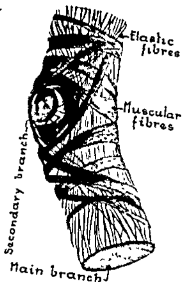


Fig 243 Disposition of the muscular fibers, looped around the origin of a secondary branch (According to Miller, The Lung)

This boy was again explored 15 days later, after his condition had improved At this second exploration bronchographic pictures were obtained which had characteristics very similar to normal, as may be seen in radiograms 244 and 245

In the initial stages of bronchial filling, branches having a normal appearance are outstanding in the lower lobe while those of the middle lobe have pathologic appearance The branches of the middle lobe have a smaller calibre and irregular conformation

The succeeding stages of bronchial filling confirmed the characteristics found in the initial stage. The branches corresponding to the lower lobe all

have a normal appearance, but in the middle lobe two branches stand out as having an irregular conformation and subnormal calibre.

As may be seen in Fig. 245, in the middle lobe area the fine branches are very scarce. This characteristic type of arborization of the middle lobe shows that the asthmatic area has been reduced and is now limited to this lobe;



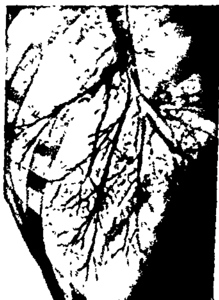


Fig 244 Initial bronchial filling The branches farther up correspond to those of the middle lobe and have an irregular calibre (Cont)

(End)

also the asthmatic condition is less intense than was noted at the first examination

Case 2. This patient is a 63 year old man who does not remember his childhood illnesses. He complains of chronic bronchitis and attacks of asthma, which began 14 years ago (1928) as a severe bronchial process [illegible] This was followed by coughing [illegible] ck yielded to simple treatment [illegible] years later (in 1932) he had a [illegible] and requiring a more compli- [illegible] Wassermann reaction and urinalysis [illegible]

[illegible] t returned to his work; but this time

he had sequelae of his late bronchitis In 1936 he had a third attack, similar in symptoms and duration to the first. In 1941 he had an attack of intense coughing with expectoration and fever, but no chest pains He finally recovered after a varied treatment, but not completely, for he had dyspnea on exertion, and sometimes for no apparent reason.



FIG 246 Direct radiogram showing manifest changes in the lung picture (Cont)

For a month before the bronchographic examination, he was in bed with a cough, frothy expectoration and dyspnea. His condition had improved, but the hissing sound from his lungs could still be heard at a distance and frank dyspnea was noticeable There were no changes in the heart rhythm, and auscultation revealed no changes in the normal sounds Lung auscultation revealed in addition to the hissing, medium and dense rhonchi, particularly in the middle field and the right lung base, anteriorly as well as posteriorly.

Previous to the bronchographic study and on the same day, our colleague R Lanza Castelli performed a bronchoscopy with aspiration, finding at that time slight changes in the bronchial mucose, more pronounced in the middle and lower lobes In these areas a reddened mucosa partly covered with mucus was evident.

Direct radiogram (Fig. 246) did not reveal any apparent changes in the

lung image; but contrast exploration of the bronchus revealed fundamental modification in the bronchopulmonary dynamics, as may be appreciated in serial radiograms 247, 248, 249 and 250. In Fig. 247 the bronchographic characteristics of the initial phase are evident, the superior lobe showing uniform filling of the bronchi and the formation of foliage; while in the



Fig 247 Initial filling stage revealing two different features in the upper, middle, and lower lobes The lower branches are filled in fragmentary fashion and are sharp.



Fig. 248 Late filling phase showing contrast between the foliage of the upper lobe and the unaltered branching of the middle and lower lobes (Cont)

middle and inferior lobes, bronchial filling is irregular, the fine branches [illegible] and therefore we find no foliage.

[illegible] onchographic characteristics [illegible] he upper region of the lung, [illegible] sponding to the middle and [illegible] n the large bronchi, without being aspirated by the fine branches and without originating foliage. These characteristics became more marked as time passed, and after ten minutes, the image obtained (Fig. 249) was almost identical with the previous one;

if the lower regions of the chest are compared in transverse position (Fig 250), the intense spasm in the bronchial branches is outstanding, for they end up in a sharp point and lack fine branchings

All these characteristics indicate spasm and hypersecretion in the bronchi found in cases of chronic bronchitis and asthma. In the complex



Fig 249 Taken ten minutes after previous one, revealing similar characteristics (Cont)



Fig 250 Image in transverse position revealing the pointed branches and absence of fine branches and foliage (End)

pathogenesis of this lung picture, these signs, revealed by contrast exploration should be kept in mind from now on.

Case 3. We are reporting this new case because we have been able to make a complete study of both lungs and the asthmatic segments are clearly shown.

This patient gave a history of asthma with critical exacerbations. He had expectoration but it was never abundant. At the time of exploration the disease was relatively quiescent, although dyspnea was noticeable on expiration

The direct radiogram (Fig 251) revealed only the blurring of the reticulum in the superior regions of the chest that occurs in emphysema, intensified in the lower regions

Bronchography of the entire lung was performed according to our tech-



Fig 251 Direct radiogram showing loss of lung reticulum in the upper areas and its intensification in the lower areas (Cont)



Fig 252 Front view, showing the irregularity of the bronchial filling, badly distributed foliage, sharpened branches, and branch spasma (Cont)



Fig 253 Transverse position image confirming findings of frontal position (Cont)



Fig 254 Lateral image, demonstrating all the bronchographic symptomatology, already described, of bronchial asthma (End)

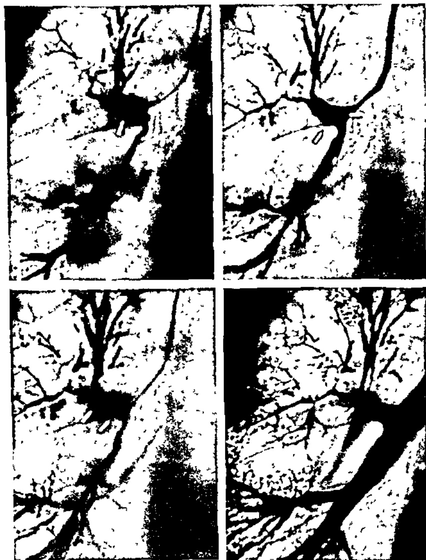


FIG 255 Serial record demonstrating the presence of numerous strangulations of the bronchial branches and of a spasm with complete closure of the anterior branch of the upper main bronchus

nique, with the exploration of one side in frontal position and then after registering the image in transverse position, proceeding with the filling of the opposite lung Thus we were able to obtain three basic images, which gave us an adequate picture of the bronchial condition.

As shown in bronchograms in 252, 253, and 254, the bronchial spasm is evident. The bronchial calibre is smaller than normal, the branches end in sharp points and frequent strangulations are noted. The foliage is distributed in a very irregular manner, abundant in some places and absent in others. Small segments corresponding to sub-lobes are observed where the contrast substance has not penetrated.

Case 4. This patient complained of lung trouble revealing a state of allergic asthma After one of his crises exploration of the right lung was carried out As in the previous cases, obstructed bronchial branches were seen strangulated by the spasm that caused the detention of the opaque medium. The images observed were registered in serial form Some of them are reproduced in Fig 255 where we have indicated the most affected sector by means of arrows In this radiogram we observe that the anterior branch of the main superior bronchus is lacking, not having been filled and that all the other branchings show strangulations and irregularities in filling The foliage is lacking in some sectors and in others it is scarce and irregular. All these images indicate a state of irritability and spasm of the bronchial tree characteristic of asthma.

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CHAPTER XI

Bronchial Exploration in Lung Carcinoma

Lung carcinomas occur predominantly in the bronchial epithelium and for this reason exploration of the bronchi is frequently indicated. Exploration may be carried out *with or without the use of contrast substances*, that is, either by tomography or *bronchography*.

Direct exploration by classic radiologic methods or by over exposure (so called penetrating radiography) has not given results that may be considered conclusive in the diagnosis of bronchial wall lesions.

The possibilities of *tomography* are limited, as only thick bronchial branches—first order bronchi—may be explored by this means. The medium and small bronchi easily escape the section plane and appear only in tomography accidentally. Tomographic exploration of the small bronchi requires great expenditure of time and money that would be better employed in obtaining graphic records which are more reliable. *Contrast bronchography*, therefore, is the method most frequently indicated when a neoplastic disease of the lung is suspected.

Bronchography, tomography and *bronchoscopy* complement one another Controversies, as to the supremacy of any one of these methods over the others, are carried on only by those who have not completely understood the use of these methods. Any one of these procedures may be the most useful in a given case, and may be of no use in another.

It is important to emphasize the order in which these procedures should be carried out as the results of one exploration may affect the results of the next. Tomography should precede bronchography, for the contrast substance remaining after bronchographic exploration causes confusing images in tomography. Bronchography should precede bronchoscopy, for this last mentioned procedure is usually followed by biopsy, which may cause hemorrhages and that would hamper bronchographic examination.

Surgeons have expressed the fear that contrast exploration might

leave the lung parenchyma in a condition that might favor postoperative lung complications, and for this reason they have advised that a period of time should be allowed to elapse between surgical intervention and contrast exploration. This hazard is not supported by statistical data and has been noteworthy only when radiologic exploration of the bronchus has been carried out without strict regard for technique.

In our opinion contrast exploration of the bronchus is entirely harmless if done skillfully and if precautions are taken after obtaining the graphic records to place the patient in an opposite position to that used when introducing the medium By this means the substance that still remains in the bronchi is almost completely eliminated through coughing.

When it is desired that the contrast substance should be rapidly eliminated, Uroselectan B., Diodrast or Perabrodil, may be used as a contrast medium since they leave traces for only a few minutes.

Before beginning this exploration it is well to keep in mind all the general contraindications to the method, namely, the bleeding neoplasm, cachexia, or the presence of some additional complicating disease.

We must not fail to mention those cancerous patients who, having been in good health up to the time of their examination, have gotten worse after the introduction of the opaque substance. Some blame the exploration itself (apparatus, technique, etc), others blame the contrast substance, that is, the iodized oil

In our examinations, these aggravated states have been exceptional, notwithstanding the fact that we have explored some patients who were border-line medical problems either on account of malnutrition or the coexistence of bacillary lesions.

After all, it is logical to find that certain bronchi, semi-obstructed by neoplasms not having yet caused an atelectasis, become completely obstructed after being explored with iodized oil, which on account of its viscosity, may cause a temporary obstruction that becomes a definite obstruction when combined with secretions

The *congestive effect* of the opaque substance upon the bronchial mucosa is not to be underestimated and it is probable that closure of the bronchus becomes complete in some cases due to edema of the mucosa caused by the iodized oil. This accident is more likely to occur in patients who are sensitive to iodine.

Hemorrhages after contrast exploration are more frequent when anesthesia has been weak and instructions to the patient have been inadequate. If the anesthesia has not been effective in suppressing the cough reflex, the arrival of the opaque substance in certain areas that are especially sensitive due to the inflammatory process itself, added to the neoplasm, causes sudden uncontrollable coughing fits, which may cause immediate intense hemorrhage.

If the patient has not been instructed to refrain from coughing as much as possible after the exploration, hemorrhage may occur.

Initial Aspect of Carcinoma

Before considering the bronchographic signs of lung cancer, let us review the actual knowledge of its appearance in direct radiograms.



FIG 256 Picture of initial nodule in *lung carcinoma*

Bronchial cancer may be diagnosed *in any of its* three principal stages, namely, the initial stage the propagation stage, and the stage of diffusion.

For our purpose, only the first and second of the three stages are of interest.

The radiologic signs of lung carcinoma vary according to their original localization. When the cancer begins in a *small bronchus of the center of the lung lobe* or a more or less central area it manifests itself radiologically, as a *nodule* of moderate density with indistinct outlines (Fig 256).

This nodule is better seen in some instances than in others

This initial lung cancer nodule is not found frequently for this lesion does not cause pain, nor does it provoke any other necessity for radiologic examination, which is the only means of discovering it. Usually, it is a slight hemoptysis that brings the patient in for an examination and it is easy to imagine all the conjectural diagnoses *made by the physician when confronted* by this initial cancer image, an image similar to those of many processes that are not neoplastic.

If the carcinoma has originated on the epithelium of a *fine bronchus*, but is localized in the *cortical region of a lobe*, the cancer becomes radiologically manifest in *frontal position* by a surface opacity, a veil of slight density and very indefinite outlines (Fig. 257). This

image is caused by the fact that the neoplasm, on propagating, encountered the parietal pleura or interlobar pleura, and as this pleural lamina serves as a barrier to the cancerous invasion, the neoplasm creeps along the surface of it It is also on account of this pleural invasion that these patients come in for a radiologic examination sooner than those in whom the process has a central initiation, for in those cases having a cortical initiation, *the pain appears much*



Fig 257 Initial image of carcinoma in the cortical region of the lung

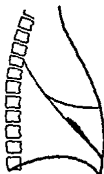


Fig 258 Initial image of carcinoma in the cortical region near the incisura

earlier When the cortical initiation has been localized in the neighborhood of an incisura, the radiologic examination in a transverse position may give us only an image of an incisuritis having a slight parenchymatous reaction, or a small opaque oval with indefinite outlines, next to it (Fig. 258).

The most useful incidences should be searched for radioscopically and, once found, should be serially recorded immediately.

The combination of the two fundamental images, *the nodule and the veil*, is of frequent occurrence, according to the anatomic circumstances of the initiation of the carcinoma.

Bronchography is not indicated in all the cases that we have just mentioned. It can only give us information concerning the canalicular state in the case of cancer developing in large bronchi; therefore all other attempts to obtain information by bronchography in slight

lung lesions that affect only fine bronchi and small areas, are useless and will only lead to failure.

However, *in the initiation stage* itself, bronchial carcinoma may give rise to gross radiologic signs which, though not pathognomic, indicate that the lesions are predominantly of neoplastic origin. We

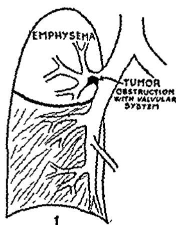


Fig 259. A sketch showing what occurs when the tumor obstructs the bronchus with a valve-like action

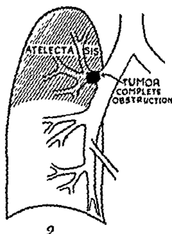


Fig. 260. A sketch showing complete obstruction of the bronchus by the tumor

refer to the initiation in large trunks, that is, in the first or second order bronchi.

If the tumor partially obstructs the bronchial lumen, it may produce a *valvular action* that allows inspiration of air but makes expiration difficult. Then we find emphysema in the affected zone, that presents a *transparency* in the radiogram, and if the localization of the tumor is in the main trunk of a lobe, the transparency extends to the entire projection area of that lobe (Fig. 259).

If the tumor obstructs the bronchus completely, we then have an *atelectasis* that is shown in the radiogram as an opacity of the area ventilated by that bronchus. Fig. 260.

In the first instance the partial obstruction of the bronchus, is the cause of retention of bronchial secretions in the stenosed area, for although the air being of light density may easily penetrate the obstacle in the large bronchus due to its expansion during inspiration, the reverse is the case with secretions since they must travel against

the force of gravity. They are unable to force their way through the obstruction because of their viscosity and the diminished calibre of the bronchus during expiration.

For this reason, the secretions are retained and obstruct *small bronchi*, giving rise to partial atelectasis that dot the lung image of the affected segment. It is the *suppurative* stage of lung cancer

For postural reasons, this image is more frequent in the bases, and only rarely do anatomic, dynamic and mechanical factors combine for the image to appear also in the upper lung fields.

With time, this *partial* stenosis will become *total* and will cause *atelectasis*. Contrast exploration may play a role in the process.

It is in this initial phase of lung cancer developing in thick trunks, in which symptoms due to atelectasis may appear that bronchography is indicated as a clue to diagnosis.

Bronchographic Images

In cases in which carcinoma begins in a first or second order bronchus, the following images may be found·

a) Lacunae or marginal effects.
b) Bronchial channels.
c) Total obstruction.

The Lacunar Image

Only exceptionally do we find this filling defect in the bronchial tube, for the anatomical changes that produce it do not cause trouble enough to compel an early exploration, which would be the only opportunity for discovering it.

This image may be found either isolated or in combination with channels Thus we have here something similar to that which occurs in the digestive tube, where gastric wall infiltration images may become associated with tumor images. To discover *lacunar images* as well as the *defects in marginal filling*, it is necessary to examine the bronchi under a screen, in order to discover small lesions and obtain the best diagnostic images We must again emphasize that in order to obtain the best results from bronchography, the correct technique must be strictly followed. An illustrative case is represented in Figs. 261, 262 and 263.

In Fig 261, we observe part of the right lung having a dense opacity limited to the base. Immediately upon the introduction of

the iodized oil into the bronchial tree, a defect in filling was noticed, which was localized in the outer wall of the common trunk for the lower and middle lobes, and a radiogram was obtained at this point. The introduction of the opaque substance was continued, and the filling defect disappeared, only an angle remaining in the bronchial wall as shown in Fig. 262 (pointed out by means of an arrow). Filling



Fig 261 Fig 262 Fig 263

Fig 261 Initial phase of bronchial filling, showing the defect in filling

Fig 263. In this radiogram the filling defect disappeared with the introduction of a greater quantity of contrast substance Arrow 1 points to the rigid angle remaining in the area of the bronchial filling defect (End)

continued and Fig. 263 shows only a sharp narrowing of the bronchial lumen. This is an abnormal finding and the physician would not have discovered it if he depended only on this radiogram for his diagnosis, nor would he have found the retention of secretions, nor the explanation for the segmentary atelectasis found further down.

Here in the bronchus, we have the same thing that happens in the stomach, when intracavitary moles or small tumors are present and

the organ is examined by means of contrast substances. Only the introduction of small quantities of the barium suspension or dosified compression allow the small defect in gastric filling to become evident, for a complete filling hides them. As we cannot use compression in the bronchi, we must utilize small quantities of the opaque substance to detect the images that are in relief on the fluoroscopic screen.

The Bronchial Defile

This is an intermediate image between the *partial filling* defect and the *complete closure* of the bronchi.

The bronchial defile has the same appearance as the esophageal and the gastric, differing from the latter because in the bronchial defile the *pre-stenotic* expansion (considering the direction of the opaque substance) does not exist and we find the post-stenotic or bronchial expansions. The channel may be due to a reduction in the lumen of the bronchi on account of an annular infiltration like a cuff or due to a tumor that growing within a bronchus, obstructs it. Cancerous ganglia that compress the bronchi from without may also produce defiles. Channels caused by neoplastic infiltration are *long*, and *central* and *tortuous*, while those due to endobronchial tumors are *short*, *lateral* and *irregular*. On the other hand, the defiles caused by an intrinsic compression of the bronchi are *long*, *lateral* and *smooth*; displacement of the bronchial axis may occur on account of the pressure exerted by the compressing body.

The images of bronchial channels are found more frequently today because bronchial exploration is done earlier. They may be masked, as happened in the following case. This patient had pain in the right chest with purulent expectoration sometimes blood stained. Some years previously he had a left lung abscess that subsided spontaneously The patient believes he now has a similar condition. Dr. Raul Oritz, who is treating him in the Rawson Hospital, believes the contrary and decides to clear up the diagnosis by means of bronchography, as laboratory tests (bacteriologic or anatomopathologic) have not been of any help in diagnosis

The results of contrast radiologic exploration of the bronchus are shown in Figs. 264, 265, 266 and 267 The opaque substance has penetrated an apparently normal bronchial tree, but looking at the segment pointed out by means of arrows, we observe that it is *strangled*, that its *border is irregular* and that the image is *persistent*



Fig 264 Initial phase of bronchial filling The narrowing of the bronchial segment common to the lower and middle lobes is evident (Cont)



Fig 265 The strangulation persists during the introduction of the opaque substance (Cont.)



Fig 266 Another plate taken on termination of filling also shows the area of strangulation (Cont)



Fig 267 Transverse position also shows the channel and the irregularity of the outline (Cont)

in the various radiograms. Only one factor can explain this image, and that is the anatomic *altering of the bronchial wall.*

Conclusions derived from radiologic examination were confirmed by bronchoscopic examination, carried out by laryngologist, Dr. R. Lanza Castelli, who noted that the part of the bronchus that



FIG 268 Initial phase of contrast exploration showing the channel in the intermediate bronchus of the right lung (Cont.)



FIG 269 End of contrast exploration giving a picture in relief of the intermediate bronchus, which brings into evidence the irregularities of the internal bronchial wall. (End)

showed the channel had a smaller calibre, and that the mucose was *ridged, congestive* and *infiltrated.* Endoscopy led us to suspect a sub-mucosal cancer, which was confirmed by biopsy obtained during the same examination

Figs. 268 and 269 show a more advanced stage of bronchial defile found in a patient with a very intense lung suppuration Both at the time of initiation of bronchial filling and at the completion of filling, the irregularity of the intermediate trunk, its narrowing, and the fringe on its internal border are evident. Bronchography and biopsy proved that it was a case of infiltrating carcinoma of the whole bronchial segment.

In Figs. 270 and 271, a typical channel is shown beginning with an infundibular image with a marginal filling defect and continuing irregularly, localized at the initiation of the common trunk for the middle and inferior lobes. The upper lobe itself is affected, for its



FIG 270. Tortuous channel in a case of bronchial neoplasm In addition to the channel in the common trunk for the middle and lower lobes, an annular strangulation of the upper lobe bronchus is seen. This radiogram was obtained at the moment of introducing the opaque substance (Cont)



FIG 271. This radiogram of the same case was obtained a few minutes after the first. It shows the presence of constant images in the common trunk. Necropsy confirmed the accuracy of our suppositions

calibre is reduced (annular strangulation). This case is more advanced than the preceding one.

The *bronchial defiles* are always accompanied by *bronchial expansions* of the cylindrical type, by *abscessed cavities and segmentary atelectasis*. The clinical picture is always that of an abscessed lung and frequently the expectoration is extraordinarily fetid and accompanied by slight hemoptysis.

Within this clinical and radiologic picture of a suppurated lung, cancer is discovered at the last moment, as we shall see in the following cases.

This patient was a thirty-one year old man who was hospitalized because his old lung trouble had recurred. He related that for the past fifteen years he had suffered from a cough with expectoration, sometimes frankly purulent, and worse on awakening in the morning. Local treatment brought only temporary relief.

For more than two months he had become worse and was conscious

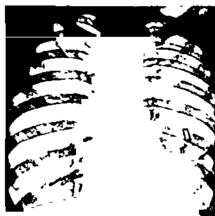


FIG 272 Direct radiogram showing opacity and cavities in left base (Cont)



FIG 273 Transverse position radiogram Here the situation in the front lobe in regard to cavities already mentioned is evident

of weakness and loss of appetite He had lost 8 to 10 lbs. in weight (Figs. 272 and 273).

Clinical and radiologic examination discovered a multicavitary, suppurative process of the left lung base. In order to have a complete picture of the localized process before submitting the patient to a sulfonamide nebulization treatment, a contrast exploration of the bronchial tree was carried out (Figs. 274 and 275)

The introduction of the opaque substance confirmed the presence of bronchiectasis in the lower lobe, an obstruction in channel form of the lower inside branch of the lingular lobe, with infiltration and stricture of the main bronchus of the lower and upper left lobes. The iodized oil did not penetrate the cavities. These signs led us to



FIG 274 Bronchogram in frontal position, demonstrating the infiltration and strangulation of the large bronchi particularly of the lower main bronchus. (Cont)

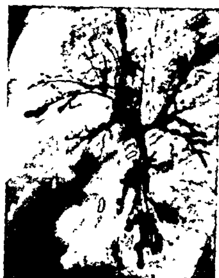


FIG 275 Bronchogram in transverse position confirming the discoveries in frontal position. Post-obstructive bronchiectasis is evident in both (End)

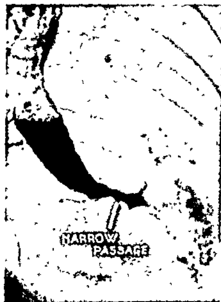


FIG 276 Bronchogram of a suppurated lung The tortuous channel stands out in the left main bronchus just before the lobular bronchi branches begin



FIG. 277 Bronchogram taken in left lateral decubitus This shows a less tortuous channel than that in Fig 276, but still localized connecting the bronchus with large cavities

suspect the presence of a neoplasm that having acquired an infiltrative and invasive character had reached the large bronchi.

Bronchoscopic study and biopsy showed these conclusions to be correct.

In Figs. 276 and 277, we see other cases having this same evolution, Fig 276 represents the bronchogram of a patient having a great quantity of purulent expectoration and a radiologic picture of massive



Fig 278 Direct radiogram showing numerous cavities in a right lung and a level at the base (Cont)

atelectasis in the left lung, causing a retraction of the trachea.

Bronchographic exploration revealed a channel which communicated with some cavities within the parenchyma of the left lung This defile affected the terminal segment of the principal bronchus and obstructed the origination of the branches of both lung lobes

Fig. 277 is a bronchogram in a case that also appeared to be a lung abscess. Within the massive atelectasis of the left lung, clear images of cavities are observed in the lung parenchyma. The channel in this case is less tortuous than in the preceding one but is more extended and communicates with large cavities.

The channel may be caused by a tumor developing in a primary

bronchus. In *the following case, the bronchographic characteristics* of this process are observed. The patient was an eighteen year old girl who had had a suppurating lung for many months with intermittent fever that affected her general health. During one of her severe attacks, she was admitted to the Rawson Hospital, Cordoba, for an emergency operation as a purulent pleurisy had been diagnosed. It was found, however, that the pleura was free, and during a second





Fig 280 Bronchogram revealing the obstruction in the right main bronchus and the channel connecting the upper lobe with the exterior. (End)

stage in the operation a large lung abscess cavity was drained. A radiogram (Fig. 278) taken after surgical intervention shows multiple *annular images in the right lung and a level may be seen* in the base. It was tomography that very clearly illustrated the causes for this process, for it brought into evidence a vegetative tumor embedded in the root of the right main bronchus obstructing the *bronchus of the* upper lobe, and leaving a channel (Figs. 279 and 280).

Bronchoscopic examination confirmed the presence of this vegetating tumor and the biopsy report was small cell carcinoma.

The Obstruction

The obstruction becomes clearly evident when it concerns primary or secondary branches. In fine branches it has no diagnostic importance, for it may be due to common causes.

Radiogram 281 shows the appearance of the left chest in a patient who complained of chest pains and slight hemoptysis. A left para-



Fig 281 Radiogram showing a paramediastinal opacity extending toward the arm-pit (Cont)

mediastinal opacity is evident in the radiogram expanding toward the arm-pit fanwise.

Bronchography proved that the obstructed branch corresponded to the opaque area, as Figs. 282 and 283 reveal.

Sputum examination showed the presence of bronchial carcinoma.

Total obstruction presents special etiologic characteristics, for stenosis may be due not only to a *tumor* that obstructs the bronchus, but also to an *external compression* or to a *bronchial agenesia*. It is necessary to know how to make this differential diagnosis, as during a definite moment in the evolution of the process, the clinical aspect may be the same in all cases. These three types of images may be observed in Fig. 284.

Neoplastic obstruction causes a sudden interruption in progress of the opaque substance. External compression gives an image similar to a flute mouthpiece. The images presented by agenesia end in a glove-finger.

The following case reveals the stenosis image, of a bronchial carcinoma.

This patient had some chest pain and slight hemoptysis. Frontal



FIG 282 Initiation of bronchial filling The arrow indicates the interruption in the apical branch of the upper forward lobe. (Cont)

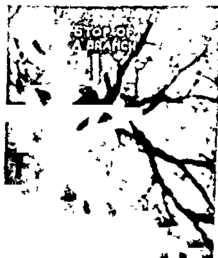


FIG 283. Image after complete bronchial filling The arrow indicates the branch obstructed by the neoplasm (End)



FIG 284 Illustrations of the three main types of bronchial obstruction Although sketches are always inadequate, anatomical facts agree so frequently with them that we must not forget them in considering bronchial images.

radiography (Fig. 285), shows an op[illegible] [illegible]alized in the middle field of the right lung, having clea[illegible] [illegible]ly, [illegible] of uniform density. The head and [illegible] [illegible]ed and accentuated, continue this [illegible] shadow



Fig 285. Frontal image revealing an opacity, well-defined, and occupying the projection area of the middle lobe (Cont)

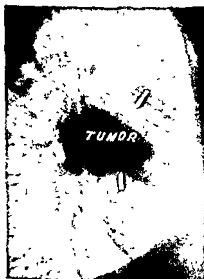


Fig 286 Transverse position image, clearly showing the area of opacity in the middle lobe (Cont)



Fig 287 In this bronchogram obtained in an oblique position, the branches of the upper and lower lobe appear normal The middle lobe branches are absent The first ventral branch of the lower lobe is strangulated at its origin (Cont)

in transverse position. A triangular shadow, well defi
lobe angle, and a neighboring hilum reaction are evi

Two incisural lines of *decreasing density leaves*
triangular shadow and indicates the limits of the mic

The bronchogram in Fig. 287 obtained in fron
position, reveals the *normal* filling of the upper

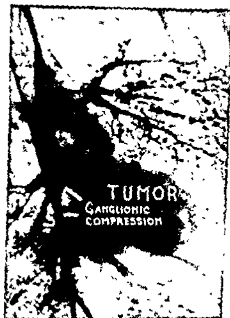


FIG 288 It is evident in this radiogram that the common trunk of the middle lobe is amputated at its base The upper lobe branches may be seen above and those of the lower may be seen below. (Cont.)



FIG. 289. The same
gram obtained a few m
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Bronchogram 288 reveals that the main trunk of th

the preceding one was obtained, when the oil had had enough time to extend along the bronchial arborization and go through any channel that might exist. The incidence of the rays has also been slightly altered. It is evident that the opaque substance has extended along the branches of the upper and inferior lobes, producing foliage, without the middle lobe becoming permeable.

Bronchial obstruction of a large lobe may be appreciated by a study of radiogram 290. This patient had clinical symptoms sug-



FIG 290 *Radiogram showing atelectasis of the upper left lobe* (Cont)

gestive of a lung carcinoma Radiographically an atelectasis of the upper front left lobe was found.

Bronchial exploration confirmed the strangulation of the left bronchus at the place where its branching begins The branches of the lower posterior lobe filled rapidly (Figs. 291 and 292), but in those of the anterior upper lobe, the contrast substance did not penetrate, due to complete obstruction at the root Histologic and bronchoscopic studies confirmed the diagnosis of lung carcinoma that had been made from the clinical history and radiographic records.

The image of total bronchial obstruction may appear in a main

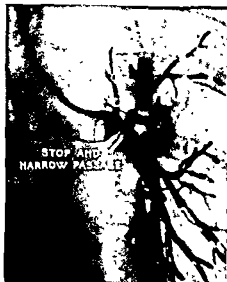


Fig 291 Initiation of bronchial filling shows a strangulation of the left bronchus at the beginning of segmentation Branching of the inferior lobe is formed but not that of the superior lobe (Cont.)



Fig 292 End of bronchial filling, revealing complete obstruction of the upper lobe bronchus (End)



Fig 293 Direct radiogram showing dense opacity clearly outlined and occupying the great part of the right lung, especially the projection area of the lower and middle lobes. (Cont)



Fig 294 This bronchogram was obtained after the principal bronchus was filled. It reveals stenosis of the common trunk for the middle and lower lobes more clearly It has the characteristics of the neoplastic stops. (End)

bronchus or even in a primary trunk, left or right bronchus, causing in these cases, a massive atelectasis of the lung on the affected side.

The following case also gives us a picture of this obstruction This patient had been suffering from a right lung process for a few months that caused pain, coughing and expectoration of a quantity of dark fetid pus Direct radiogram (Fig. 293) shows that the right chest is occupied mainly by a shadow showing clear outlines and great

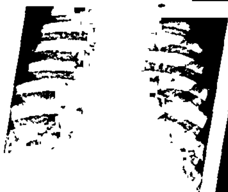


Fig 295 Image in frontal position. A shadow is seen that has precise limits and is apparently the heart outline (Cont)



Fig 296 Image in transverse position The shadow at the base with a clearly defined anterior limit is evident (Cont)

density. Sputum analysis direct or by inclusion, showed no neoplastic cells. A bronchographic study was decided upon, the results of which may be seen in radiogram 294 Here it is evident that the upper lobe branches are permeable, but that the common trunk for the middle and lower lobes is completely obstructed.

When the obstruction has caused atelectasis of one lobe, the other expands and occupies the space left by the retracted lobe If the clinical signs are not evident this atelectasis may pass unnoticed in the direct radiogram, especially since it is obscured by the shadow of the heart when it corresponds to the lower left lobe

We have explored one of these patients with direct frontal radiograms without discovering the lesions Only after several months was left pericardiac shadow observed, clearly limited and that in soft

radiograms seemed to be the heart outline. In a transverse position radiogram, an opacity was observed in the base, having a posterior localization, uniform density and anterior limits well defined (Figs 295 and 296).

Contrast exploration of the bronchial tree brought two facts into



Fig 297 Bronchogram obtained in frontal position The interruption in the lower lobe may be observed and also the expansion in the superior lobe. (Cont)



Fig 298. Transverse position bronchogram. Note expansion of the bronchial tree of the upper lobe The stop in the lower lobe is emphasized

evidence. One was the expansion of the left upper lobe. The lower, inner and posterior position of the lingual lobe was especially evident (Figs. 297 and 298). The other observation was the finding of an obstruction in the lower lobe next to the site of origination of the main bronchus.

The characteristics of the immediate bronchial walls indicated an infiltration beyond the site of the obstruction. A l these deductions were confirmed by bronchoscopy, and biopsy verified the presence of a carcinoma.

Bronchographic Control of the Therapeutic Effect

The utility of the contrast method can go beyond a mere contribution to the diagnosis and localization of the neoplastic process; it

can record the therapeutic effect of radiation, as evidenced by the disappearance of the bronchial obstruction.

This possibility has been well demonstrated in the following cases:

Case 1. Illustrated in Figs. 299, 300, 301 and 302

In the direct radiogram (Fig 299), the opacity of the chest in the projection area of the upper lobe is observed, and bronchogram 300 shows an interruption of the opaque substance next to the origin of the main upper lobe bronchus and a narrowing of the lumen of the lower main bronchus, due to a compression of the ganglion These deductions were confirmed by bronchoscopy and biopsy verified the neoplastic etiology of the obstruction in the superior bronchus



Fig 299 Direct radiogram showing an opacity in the left lung in the projection area of the upper lobe (Cont)



Fig 300 Bronchogram bringing into evidence the detention of the opaque substance at the base of the main upper trunk and external compression of the lower one due to a ganglion (Cont)

The patient was placed under irradiation treatment and one month after the termination of this therapy he was again explored The direct radiogram (Fig 301) showed that the atelectasis of the upper lobe had disappeared and bronchography (Fig 302) brought into evidence the disappearance of the obstruction in the upper main bronchus with complete permeability of the branchings The beneficial effect of roentgenotherapy on lung neoplasms originating in the large bronchi is not of exceptional occurrence, though the evident disappearance of the physical signs following this type of therapy does not mean that the neoplasm has been cured



Fig 301 Direct radiogram obtained after x-ray therapy showing that the opacity in the upper lobe has disappeared (Cont)



Fig 302 Bronchogram bringing into evidence the disappearance of the obstruction in the upper main trunk, and the complete permeability of the foliage (End)





Fig. 303 Direct radiogram showing left pericardiac shadow. (Cont)

Case 2. The beneficial result of irradiation has been observed by us also in a patient who presented an atelectasis of the lower lobe of the left lung Direct *radiography* (Fig. 303) shows us a left pericardiac opacity having *indefinite limits* Contrast exploration (Fig. 304) showed the obstruction





Fig 305 Bronchogram obtained after irradiation, showing that the obstruction in *the lower lobe has disappeared (Lat.)*

chus For this reason the possibilities of radiation therapy only were considered and irradiation was effected with a Maximar equipment of 400 Kv, Filter 2 mm copper, focal distance 80 Cm., double penetration entrances Forty-five days later another contrast exploration was carried out (Fig. 305) revealing the disappearance of the obstruction and the complete permeability of the bronchial tree of the lower lobe. This *local improvement* lasted several months; later mediastinal and brain *metastasis occurred causing* death.

Abscessed Cancer

A lung neoplasm sometimes takes on the appearance of an abscess cavity, simulating various processes Lung abscess, suppurated hydatid cyst, suppurated congenital cyst, etc.



FIG 306 This radiogram shows the cavity in the left base and the involvement of the costodiaphragmatic sinus of the same side The density of both hilums is also evident. (Cont)

Case 1. This patient had a subacute suppurated lung process, which seriously impaired his general health.



FIG 307 Same case, transverse position. *The cyst containing liquid and the incisuritis stands out clearly. There is a large nodule over the cyst.* (Cont)

Frontal radiogram (Fig. 306) reveals an opacity of the left base, having the appearance of a large cavity with a liquid content, indicated by the level. There is also an opacity of the costodiaphragmatic sinus on the same side and a clearly limited perimediastinal shadow.

The transverse radiogram (Fig. 307) shows a cystic image having a liquid retention and frank condensation of the walls We may also observe an incisuritis, corresponding to the large left incisura. In the region of the hilum we may observe a nodule that crowns the cystic image. It is not very probable that an accurate diagnosis may be made from these clinical and radiologic data. Nor did the laboratory tests help us to clear up our doubts, for they revealed

a finger and the other like a prominence. These salients indicate the presence of neoplastic moles on the wall of the cavity This sign is so significant that it



Fig 308 Tomogram of the same case There are moles dangling from the dome of the cavity, thus indicating its neoplastic character (Cont)



Fig 309 Bronchogram of the same case,



Fig. 310 Bronchographic image in the same case, obtained after the bronchial tree was filled The displacement of the lower branches and the amputation of those reaching the dome of the cavity may be seen. (End)

of a suppurated hydatid cyst. It should be remembered that there are also prominences within the hydatid cyst, due to the retention of the germinative membrane, but these prominences are upon the liquid, as the membrane floats (sign of the camalote). When the neoplastic mole is found, not on the upper wall of the cavity, but on the lateral one, at the height of the liquid level, the image may cause confusion in diagnosis In that case, to make sure whether it is a neoplastic sprout or an *hydatid "camalote,"* it will be necessary to resort to changes in the position of the patient, giving the chest various inclinations The neoplastic images do not modify their relations with the wall of the tumor formation, while the hydatid camalote is seen floating on the liquid level (Fig 311)

Case 3. A similar case is that of a woman 40 years old who complained of chest pains accompanied by hemopurulent expectoration. The direct radiogram (Fig. 312) demonstrated the presence of a cavitary image having very thick irregular walls, with a liquid content This cavity occupied the lobe of the linula in its most internal forward portion Tomography (Fig. 313) revealed the presence of several neoplastic moles in the upper inner wall of this cavity which confirmed the diag-



Fig 311 Sketch showing how a doubtful image within a cavity is cleared up By giving the chest an appropriate inclination, we may see that the hydatid camalote always floats, in any position, while the neoplastic mole separates from the liquid and hangs from the inner wall of the cavity.

nosis of excavated carcinoma As in the preceding case, bronchography did not reveal changes in the bronchial branches nor did the opaque substance succeed in penetrating the cavity for the communication of the latter with the outside is always small, and also because the absence of thoraco-alveolar



FIG 312. Direct radiogram showing a thick walled cavity with a liquid level (Cont.)



FIG 313 Tomogram bringing into evidence a neoplastic mole in the wall of the cavity (Cont.)



FIG 314 Bronchogram proving that the iodized oil has not penetrated the cavity and that only the fine branchings are absent in this area. (End.)

aspiration in this segment makes the progression of the iodized oil difficult (Fig. 314)

Obstruction of the Lobe Branch by an Infiltrating Tumor

The neoplasm may cause segmentary obstruction of the bronchial tree, causing, as we have seen previously, an atelectasis in the area ventilated by the obstructed bronchus.

This obstruction of the bronchus may be caused by a tumor



Fig 315 Frontal image showing a left pericardiac opacity of polycyclic outline and indefinite limits (Cont)

originating in the epithelium where a lobe branch originates, causing a *typical atelectasis*.

If the tumor originates in one of the small fourth order branches and later infiltrates the lobe, the time comes when the main trunk of this lobe is also obstructed In this latter case, the opacity on direct radiogram has combined characteristics of *lobar atelectasis* and *nodular image*.

This distinction is important, for the surgical possibilities differ according to the type of neoplasm. When the carcinoma has originated on a small bronchiole and by infiltration later causes a sublobar or lobar atelectasis, it has also caused metastasis in the mediastinal ganglia or has infiltrated the pleura. By the time the diagnosis is certain, it is generally too late to operate. In these cases bronchoscopic examination is not conclusive, for the obstacle cannot be seen nor can material for biopsy be obtained On the other hand, when the tumor originates in the main bronchus of a lobe, it causes evident and early signs that necessitate medical and radiologic examination, and therefore diagnosis is made much earlier Endoscopic examination permits us to see the tumor and obtain conclusive biopsy evidence.



FIG 316 Transverse position image, showing an opaque area that has no relation to the heart shadow (Cont)

Case 1. In the following case, the radiologic and bronchographic characteristics that appear in direct radiograms in the case of an infiltrative tumor may be appreciated

This man was 55 years old For a couple of months he had been aware of trouble in the anterior chest, with pain on expiration. His general health had evidently been impaired, but the patient attributed this to the fact that he had had fever during the days preceding the examination together with a general state of low spirits of the influenza type Recently, in addition to fever, he had a cough with slight purulent expectoration

Auscultation and percussion of the chest revealed no abnormal sounds. Direct frontal radiography evidenced a left pericardial opacity with a

lobe, and due to its nodular character, and a blurred and polycyclic outline, we are led to suspect lung cnoplasma of infiltrative and parenchymatous origin

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Sputum examination revealed no neoplastic cells or specific bacteria *Endoscopic* examination carried out by Dr. Lanza Castelli, showed that the lingula lobe was patent at its beginning; but 2 cm. farther on, a prominence covered by mucus was observed. A biopsy specimen from this region showed no neoplastic cells.

Bronchographic study revealed the amputation of the main branch of the lingula lobe, a couple of centimeters from its origin. The interruption of the



Fig 317 Initial filling phase revealing the amputation of the main lingula lobe trunk Front view



Fig 318 Intermediate filling phase, revealing the persistence of amputation of the lingula lobe bronchus (Front view) (Cont)

was evidenced by a blurred outline of the opaque substance at the point of interruption in the tortuosities of this outline. This type of obstruction is ca[illegible]

I[illegible]

co[illegible]

various incidences In Fig 317, the initial phase of filling has been recorded, and the arrow indicates the amputated branch, that having a forward direction, mounts over the rest of the main upper trunk. Fig. 318, represents an intermediate phase of filling, where similar characteristics are evident. Oblique incidence allowed us to make a more convincing registration, not



FIG 319 Final filling phase seen in oblique position A, D, where the interruption of the iodized oil is evident a couple of centimeters away from the initiation of the lingula lobe branch The boundary of the opaque substance is ragged

only of the amputation of the lingula bronchus but also of the characteristics of the detention Fig 319 As we have already stated, the outline of the contrast substance at the point where it has been detained was tortuous and ragged, indicating contact not only with the solid tumor but also with secretions

Figs 320 and 321 demonstrate what occurs when the tumor originates in a bronchiole and invades the parenchyma, or, when having origi-

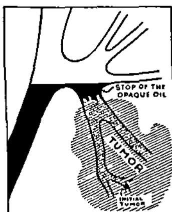


FIG 320 Drawing showing how the opaque substance is interrupted when the tumor has infiltrated the bronchus The limit of this detention is not well defined

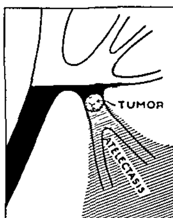


FIG 321 Drawing showing the sudden detention of the opaque substance when an endobronchial tumor obstructs the branch The limit of the detention of the opaque substance is clear

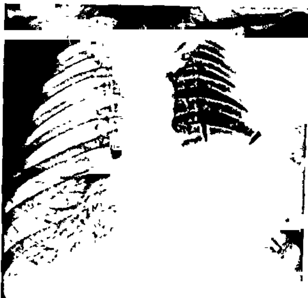


Fig 322 Frontal image showing an opacity localized in the base of the left lung, having definite limits and uniform density (Cont)



Fig 323 Transverse image in the same case showing the characteristics found in the front view. (Cont)

nated at the root of a sub-branching or lobe branch, causes the destruction of the bronchus.

In both cases a shadow is observed in the site of the tumor This opacity indicates the very limits of the tumor, when after originating in a bronchus it later infiltrates the parenchyma. When the process has caused an atelectasis on account of the obstruction of the main bronchial branch at the point where it originated, the opacity indicates the limits of the sub-lobe or the lobe

Bronchographic study permits differentiation of these types of neoplasms, for when the tumor has originated at the very beginning of the bronchial branch, the opaque substance is interrupted next to it and the limits of this detention are clear. On the other hand, when the tumor has originated in a small branch and has then invaded the lobe, obstructing the branch near its starting point, the opaque substance has a ragged outline, caused by the secretions that are retained within the bronchus and by the lack of normal dynamism.

Case 2. This case also illustrates the dynamic changes caused by neoplasms infiltrating the bronchial wall, but not causing obstruction of the bronchial lumen

The patient, 45 years old, had pain for several months in the left chest, with a cough and purulent fluid expectoration The previous history, the clinical course, and the results of laboratory investigation did not provide a definite diagnosis Neither did the direct radiogram, Figs 322 and 323, permit us to come to any other conclusion than that it was a case of a localized process of the left lung producing a circular opacity with regular outlines and uniform density At the hospital where the patient was being treated there was a tendency to diagnose lung hydatid cyst and this supposition was strengthened by the results of the bronchoscopic examination, where neither obstacle nor deformity was found in the main bronchus of the lower lobe.

With a probable diagnosis of lung hydatid cyst, a contrast exploration of the bronchial tree was requested in the hope of finding the dislocation of the bronchial branches that would confirm the diagnosis of hydatidosis

Contrast exploration proved the presence of *bronchoparalysis of the lower left trunk* Here the opaque substance penetrated only the larger bronchi The secondary branches were not penetrated because of the absence of thoraco-alveolar aspiration which facilitates the progress of the contrast substance in the fine bronchial tubes (Figs 324 and 325)

This lack of progression of the contrast substance is an undeniable characteristic of neoplasms that having originated in the fine bronchi, progress by infiltration as they extend to the larger bronchi. This infiltration may not cause an obstruction of the lumen but does cause paralysis that gives us a very definite characteristic picture in the bronchogram

This discovery and the absence of bronchial dislocation led us to the certainty that it was a neoplasm, and this was confirmed by explanatory puncture.



Fig. 324 Bronchogram obtained during intermediate filling stage. The lack of progression of the opaque substance in the lower lobe may be observed. (Cont.)

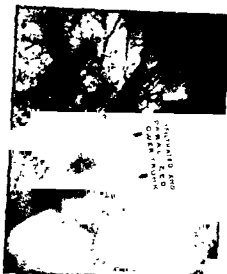


Fig 325 Bronchogram in transverse position showing the same characteristics





Fig 326A *After the opaque substance is* introduced, an obstruction in the lower and middle common trunk stands out The opaque substance forms a lateral defile that communicated with expanded bronchial branches (Obtained in standing position and anterior left oblique.) (Cont.)

Fig 326B Bronchogram obtained a few moments after the previous one, to show that the obstruction is persistent. (Obtained in standing position and anterior left oblique) (End)

Pseudoneoplastic Images—The Bronchial Adenoma

Radiologic exploration does not give us images of absolute d[iagnostic] value. It gives us information only as to the degree of can[alicular] patency and the characteristics of the obstruction of branches and their foliage; *under no consideration is it justifiable to deduce the histology of the obstruction from its type.*

A very clear example of the error that may occur if we examine only the bronchograms and not the patient, is illustrated in the following case of Dr. T deVillafañe Lastra. The clinical history revealed a chronic lung process having acute exacerbations during which purulent hemoptoic sputum was always present. The general condition of the patient, notwithstanding temporary elevations of temperature, was not greatly impaired, and for the past two months he had shown a notable improvement. The direct radiologic picture was characterized by an opacity of the right base and the right paramediastinum The result of the bronchographic study is shown in Figs. 326A and B which confirm the presence of a channel caused by partial obstruction of the main trunk for the middle and inferior lobes. Due to the persistent characteristics of this image, it cannot be doubted that it is due to an immutable organic obstacle, and one is inclined to suspect that the obstacle is of neoplastic nature.

Let us analyze the images shown in the figures more closely, before being positive as to their neoplastic nature

Two principal features are prominent in Figs 326A and B First, the defile is *not tortuous* and second, the bronchial branch *has been repulsed toward the middle line.*

We have stated that the neoplastic defile was characteristically tortuous and it could be *eccentric*, when the obstacle had originated in a bronchial wall, leaving it permeable on the opposite wall In the first case the defile is long and in the second case it is short. It was not possible to carry out a bronchoscopic examination of a biopsy in this patient, and the bacteriologic examinations revealed only mycotic flora that are usual in bronchiectasis. The clinical course and the bronchographic examination led us to suspect the presence of a bronchial adenoma.

In Fig 328 we have sketched these various types of defiles The channel caused by a neoplastic *infiltration* is central, *tortuous* and long The defile caused by a *tumor* occupying the bronchial lumen is *lateral, tortuous* and *short*. The defile caused by an external compression



FIGS 327A and 327B In the direct radiogram, 327A, the opacity of the right base is observed, and in 327B the bronchial obstruction caused by an adenoma

is, *lateral*, *smooth* and *long*. A displacement of the bronchial axis may exist which is visible in certain appropriate instances.

In the cases represented by Figs. 326 and 327, we can not accept the possibility of a neoplastic obstruction, for the defile is *lateral*,



FIG 328 Characteristics of the various channels 1, Tortuous defile due to neoplastic infiltration, 2, defile caused by a neoplastic tumor; 3, due to extrinsic compression.

smooth and *long;* moreover, there is a typical displacement of the bronchial axis toward the middle line. It has not been possible to obtain bronchoscopic data on this case.

The following type of case also may cause diagnostic confusion,

if the physician's conclusions are based only on the radiologic image. The patient, a woman, was examined by Dr. T. deVillafañe Lastra and by Dr. J. Maluf, on account of a slight cough with expectoration. Examination disclosed few definite findings but direct radiography showed a large area of opacity with very indefinite outlines but of



Fig. 329 Frontal image showing an area of uniform opacity in the left lung (Cont.)

uniform density, occupying nearly the whole left lung. In transverse position it is seen that this opacity occupies the middle part of the lung field and has clear border lines. Before and behind this shadow we find that the parenchyma is free (Figs. 329 and 330).

Tests for hydatidosis gave negative reaction and the sputum examination gave no diagnostic clue.

Bronchial exploration seemed indicated and the results of this study may be seen in Fig. 331, where a typical obstruction of the upper front lobe main branch is evident.

This obstruction decided the diagnosis in favor of a bronchial neoplasm. Nevertheless, Professor Villafañe performed an explora-

tory puncture and obtained a crystalline liquid in which hydatid hooks were found. Surgical intervention revealed an enormous hydatid cyst of the upper front lobe, which had compressed the bronchus. The bronchial adenoma causes defiles and stop similar to



Fig 330 Transverse image showing the position and limits of the opacity (Cont)



Fig 331 Result of bronchial exploration; a typical obstruction picture similar to that of an endobronchial neoplasm (End)

those caused by carcinoma. It is only possible to differentiate them during the radioscopic act while the opaque medium is being introduced, for in the case of a bronchial adenoma the bronchial wall conserves its dynamism up to the place where the tumor begins as the adenoma does not infiltrate the wall as the carcinoma does it.

Thus the bronchus expands during inspiration and gets narrower during exspiration or coughing in case of adenoma.

In Figs. 327A and 327B we show the direct radiogram of a patient, 20 years, with old hemoptysis and pulmonary suppuration. The opacity of the right base is observed.

The bronchogram showed a defile in the main lower bronchus but in the radioscopy the normal dynamism of the bronchial wall could

be clearly seen, which permitted us to assure the existence of benign disease that was later confirmed by the endoscopy, biopsy and surgical intervention It was a case of bronchial adenoma.

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CHAPTER XII

Exploration of the Bronchial Tree in Cases of Lung Hydatid Cyst

The parenchyma of the lung, as well as of the bronchial tree, alters its anatomoradiologic characteristics in the site of echinococcus nesting, but only under certain circumstances do these modifications demonstrate radiologically the presence of the parasite

The radiologic features of the lung hydatid cyst differ according to the stage of evolution of the cyst or its complications. The lung hydatid cyst may appear as:

1. **A cyst not radiologically complicated:** of varied size and situation, sometimes superficial and sometimes deep
2. **A radiologically complicated cyst.**
   a) Inflammatory adventitia or neighbouring tissue reaction (Inflammation of adventitia, pericystitis, corticopleuritis, etc)
   b) Freeing of the hydatid vesicle
   c) Partial or total retention of the parasite membrane, that floats in a purulent liquid (pyopneumocyst).
   d) Retention of the parasite membrane (incarcerated membrane).
3. **Residual processes.**
   a) Postvomica or surgical residual cavity without the membrane.
   b) Hydatid residual bronchiectasis

Direct Radiographic Image

The closed cyst may appear, in direct radiography as a uniform, circular or oblong-shaped opacity, having a smooth and clearly limited outline. The presence of a hydatid cyst is not clearly revealed by the foregoing characteristics, as other benign or malignant diseases may exhibit the same features.

The image of the enclosed cyst may not have these characteristics, on account of possible complications such as pericystic inflammatory

reaction from an additional infectious process in the tissues lacking normal ventilation. When this pericystic process occurs, the image that we have described as having clear outlines and being spherical or oval shaped, is lost, and the cyst then assumes a radiologic aspect of a pneumonic, cancerous or corticopleuritic process that completely masks the initial process.

The closed hydatid cyst may present an image that is pathognomonic and that confirms beyond question the presence of the Echinococcus. We refer to the fissuring of the cyst that causes a

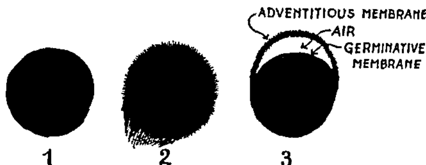


FIG 332 Drawings representing the radiologic aspect of hydatid cyst of the lung in a direct radiogram 1, unruptured cyst, 2, the cyst with an inflammatory reaction, 3, sign showing detachment of cyst

separation by a layer of air that settles between the adventitis and the germinative membrane. This partial separation of the cyst into a quadrant gives a characteristic radiologic image which has been designated as *pneumopericyst* by Morquio, Bonaba and Soto (Montevideo, S.A.)[1] and other authors have called it "detaching" sign (Fig 332).

If the cyst has ruptured into a bronchus and has given place to a partial vomica, its contents may cause another characteristic image in a radiogram obtained directly in a standing position. We refer to the *sign of the "camalote,"* so called by C. Lagos Garcia and A. Segers.[2] In describing the differential radiologic signs between cystic pleurisy opening into a bronchus and the semi-evacuated hydatid

[1] "Archivos de Pediatria del Uruguay," Num 9, 1934
[2] "La Semana Medica," Buenos Aires, 1924

cyst, they state "if we have a semi-evacuated hydatid cyst, at certain moments and over the horizontal level there appears an irregularity, as if a solid body were floating in the liquid." This solid body is formed by the germinative membrane that being retained and lighter than the pus, floats. It then looks like water plants on the banks of a river (camalotes), that float, rise or sink with the movements of the water. Due to this likeness it is called. "*sign of the camalote*" (Fig. 333)

The emptying of the cyst into the bronchus and the fragmentary retention of the membrane, may cause suppuration of the contents,

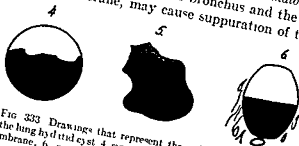


FIG 333 Drawings that represent the radiologic appearance of the lung hydatid cyst 4, sign of the "camalote", 5, incarcerated membrane, 6, residual cavity showing bronchiectasis

a neighbouring inflammatory reaction that may result in the sclerosis enclosing of the draining bronchus, imprisoning the membrane

In these cases there is no pathognomonic sign to indicate the etiology. It may look like a condensation having a polygonal outline (Ivenissevitch's sign) Tomography may reveal the presence of the retained membrane in a dry cavity.

The hydatid cavity sometimes remains even after the membrane has been expelled, and this residual cavity in turn may be accompanied by hemoptysis and bronchorrhea. Then the clinical picture has the appearance of tuberculosis or lung abscess, and the real etiology is not suspected

The lung tissue in the neighbourhood of the cyst or its remains also undergoes changes, with the production of sclerosis and bronchiectasis.

Of all the signs given by direct radiography, only the *pneumopericyst* and the *sign of the camalote* unmistakably reveal the existence of Echinococcus infection

Bronchography can give other positive information to support the diagnosis of hydatid cyst, and in some cases provides accurate

information regarding the state of the cyst, its vicinity or its extension.

The eccentric growth of the cyst gives place to the repulsing of the bronchial branches; but for this sign to be evident it is necessary that the cyst have a certain size and to be situated not too near the margin.

The small cysts with a 3 to 5 cm diameter cause no appreciable deformity of the distribution of the bronchial branches, as the bronchi are displaced by the expansive growth of the cyst only when it attains a greater size and gives place to very characteristic images (Fig. 334).

This sign has been described by R. Piaggio Blanco and F. Garcia Capurro (of Montevideo) under the heading of *Bronchial Dislocation*

Due to the diagnostic importance of this sign, and the fact that these authors were the first to describe it and emphasize its importance it should be called Piaggio Blanco and Garcia Capurro's sign.

It is unusual to find other chest processes having growth characteristics similar to those of the echinococcus cyst; for this reason Piaggio Blanco and Capurro's sign may be accepted as pathognomonic if the bronchial displacement has been proven.

In only one case have we found that Piaggio Blanco and Garcia Capurro's sign was not caused by a hydatid cyst. This patient, 45 years of age, came to us for a bronchographic study. His history shows that up to a year ago he had never been ill. He began having pains in the left chest which allowed him no rest by day nor by night, and had to be relieved with aspirin tablets. The patient was depressed and sometimes feverish. Neither his appetite nor his weight was affected.

The pain gradually increased and a cough developed which aggravated the pain. Coughing was followed by expectoration, at first mucopurulent and then blood-streaked After his admission to the hospital he began to have a fever that did not rise higher than 38°C. Radioscopic examination revealed a nodular shadow in the left chest The Casoni reaction was positive and later the Weimberg-Ghedini test logically also gave a reaction.

The patient became worse and a left preaxillary ganglion appeared. He was admitted to Professor Mirizzi's Surgical Clinic and here an extensive nodular shadow was found on the radiogram, occupying the medical region of the left chest, with a part of the rib destroyed.

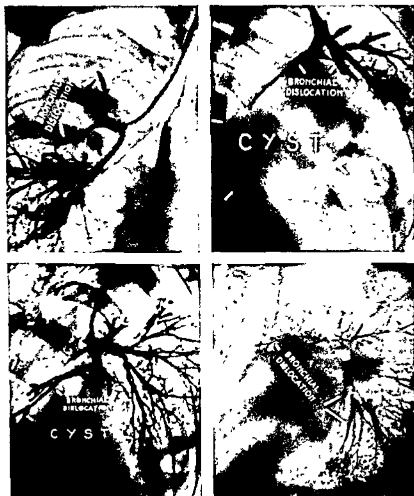


FIG 334 Four typical bronchial displacements caused by the unruptured hydatid cyst in different patients

The presence of a left preaxillary ganglion and a painful thickening with adherent skin on the medial third of the fifth left rib, favored the diagnosis of a pleuropulmonary neoplasm inoperable on account of the unfavorable conditions (adherence to the wall and ganglion propagation).

The patient was transferred to the service of the medical clinic where the following interesting information was obtained. In the left chest, over the middle third of the fifth rib, a tumor was found adhering to the skin and deeper tissues, painful on pressure, hard, without crepitation, with a slight reddening of the skin. In the preaxillary region on the same side there was a rather adherent, painful and solitary ganglion. The breathing excursion in the left



Fig 335 Frontal radiogram bringing into evidence a nodular image with intensified opacity in the centre The arrow points to a destroyed rib (Cont)



Fig 336 Image in transverse position showing a double nodular image (Cont)

chest was reduced, also the vocal sounds. Percussion revealed a zone of dullness in the mammary line and middle axillary, between the second and sixth ribs. Anteriorly it became confused with the cardiac dullness. Traube's space was free. Auscultation revealed a blowing respiration behind and above the zone of dullness. In this zone of dullness and above the zone of dullness and in front of it, the vesicular murmur had disappeared. In some areas numerous fine crepitant rales were heard.

In addition to what could be observed in the frontal radiogram, the plate distinctly showed the destruction of a segment of the anterior third of the fourth rib 5 cm. in length. This type of destruction was

similar to that caused by compression and not by neoplastic impregnation, as there was no rubbing out of the mesh but only of small portions (Figs. 335 and 336).

The Weimberg-Ghedini reaction was positive. The red blood-cell count was normal. White blood-cells numbered 13 400; Eosinophiles 7% having 78% polynucleated cells.

There were no neoplastic cells, nor were there hydatid hooks in



Fig 337 Initiation of the bronchial filling showing the repulsion of the forward descending and axillary branches The branches are flattened (Cont)



Fig 338 Final filling phase in which findings on first examination are confirmed, that is, the dislocation of the descending, forward, and axillary branches of the upper lobe (End)

the sputum. Sedimentation test gave the following results in half an hour 22mm., in an hour 50. Katz index was 51.

Biopsy of the ganglion showed a thickened capsule and the presence of intense proliferative phenomena of the reticuloendothelial elements. There was no evidence of malignancy

Bronchographic exploration was carried out with the object of searching for the bronchial dislocation that should have been caused by the hydatid cyst, as all signs pointed toward this diagnosis.

As we may see in radiograms 337 and 338, Piaggio Blanco and Garcia Capurro's sign, that is the bronchial dislocation, was clearly present.

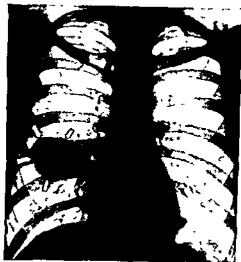


Fig 339 Front view image showing an opacity occupying the central part of the right lung, with uniform density, smooth and clear outlines (Cont)



Fig 340 Transverse position radiogram Here the image changes its spherical appearance and in some places there is a superposition of opacities, as is evident in the lower anterior region (Cont)



Fig 341. Frontal position bronchogram showing that the cyst does not cause displacement of the bronchial branches (Cont)



Fig 342. Bronchogram in the same case, taken in profile, confirming that the bronchial branches have not undergone displacement due to the suspected cyst. (End)

With a diagnosis of hydatid cyst this patient was operated upon. The operation revealed a poorly outlined sac adherent to the rib wall, having a caseous content. The histologic study of a portion of the apparent membrane that limited the process, proved it to be a *carcinoma*.

This case proves to us that notwithstanding apparent pathognomic signs, one must be cautious when interpreting them, even though the patient's history and the clinical data appear to confirm them. We must remember that nearly all diseases are diagnosed radiologically through syndromes and not by signs

Let us now review the various bronchographic aspects of the hydatid cyst, closed or open, and its sequellae.

BRONCHOGRAPHY IN CLOSED CYSTS

A Case of a Closed Cyst Having a Small Diameter and Central Situation

Fig. 339 shows a chest radiogram in which a uniformly opaque image is evident. Its outlines are smooth and clear, occupying the centre of the right lung A fine granulation is clearly evident over this image; it is caused by the remains of opaque oil used for exploration some months previously.

Fig. 340 shows the same case in a transverse position, giving the impression that two opacities exist, riding one upon the other, especially in the anteroinferior portion.

In this case there was no indication of the presence of Echinococcus, as the Casoni and Weimberg-Ghedini reactions were negative. The only clinical data was a slight chest pain increasing on deep inspiration It was this pain that led the patient to seek medical advice. The patient also had urticaria There were no blood alterations

No decisive data were obtained on bronchography, as is evident in Figs. 341 and 342 There were no changes in the position or the form of the bronchial branches. Nevertheless bronchography was very useful to us, as by showing the anatomical position of the branches, it enabled us to determine the position of the cystic image, which had been a point of discussion up to that moment

As may be seen more clearly in Fig. 342, this image was situated between the infraincisural branch of the middle lobe and the anterior branch of the superior lobe, that meant it had to be positively in a marginal position in one lobe, or, an interlobar position exactly where

the horizontal incisura begins. In view of this localization and in the absence of a precise diagnosis, but accepting the possibility of its being a benign tumor, the patient was operated upon by Dr. L. Langer in the Surgical Clinic Service under Professor J. M. Allende. The pleura was dissected at the point where the horizontal incisura separates from the oblique incisura, at the highest posterior portion of the middle lobe. Here a cystic tumor about the size of a hen's egg was found covered over by a small lung lingula (Fig. 343). The

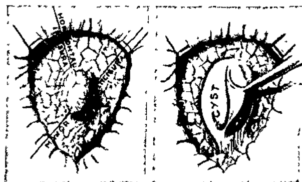


FIG 343 A, appearance of the cyst before the pleural dissection B, the cyst before enucleation (Drawings made during operation performed by Dr Oscar)

lower end of the tumor rested upon the incisura and this plane was utilized for its complete enucleation. Histologic study confirmed the diagnosis of hydatid cyst.

The postoperative course was satisfactory and the patient returned to his normal occupation one month after the operation.

This case illustrates the fact that the hydatid cyst may appear both clinically and radiologically under unrecognizable aspects.

A Case of Small Marginal Spindle Shaped Cyst

When the lung hydatid cyst is small and situated close to the chest wall, it does not cause dislocation of the large branches, but repulses the small ones. These surround the cyst and localize it These characteristics demonstrate the expansive growth of the process that repulses the tissue from the site of its implantation.

Fig. 344 is a direct radiogram of the chest wall showing one of these marginal cysts occupying the middle zone of the left lung.



Fig 344 Left marginal cyst (Cont)



Fig 345 Transverse position radiogram, the cyst is hidden in the upper darker areas (Cont)



Fig 346 Transverse position tomogram, showing position and conformation of cyst (Cont)

Fig. 345, is the same case in transverse position, where the presence of the cyst is not clearly seen, since in this position it occupies the most opaque projection area of the chest.

For this reason a tomogram was obtained in a transverse position, revealing the position and oblong conformation of the cyst (Fig. 346).

In a case of this type bronchography cannot show the displacement of the large branches, because the cyst is small and has a marginal



FIG 347. Initial, intermediate, and final filling phases showing the displacement of the small marginal branches that surround the cyst (End)

position, but the small branches that surround it undergo a similar displacement which shows clearly the etiology of the process.

In Fig 347 is shown part of the serial record of what happens in the bronchus during filling with an opaque substance. In the three principal phases of this filling; initial, intermediate and final, we may observe that the displacement of the uniform and the opaque column is frequently interrupted. This was due to the fact that the patient had a slight bronchitis and the secretions displaced the opaque substance.

Case of a Closed Hydatid Cyst With a Large Diameter and Marginal Position

When the closed cyst occupies a marginal position in the chest, even if it is very large, it does not cause a displacement of the bronchial branches, but only a repulsing of the parenchyma and its fine bronchi.

Figs. 348 and 349 represent a radiogram of the chest of a patient suffering from a pain in the chest and a cough. The frontal image is

not conclusive, but the transverse position picture clearly reveals the anterior position in contact with the wall and verifies the diagnosis, for in the lower part of the image, a ring shaped shadow stands out with the radiologic characteristics of the hydatid calcified cyst. Laboratory tests for hydatid cyst proved positive.

In the contrast study of the bronchus, interesting images were obtained (Figs. 350 and 351) at the beginning of the bronchial tree

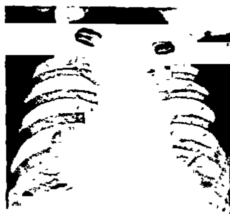


Fig 348 Front view image showing a right pre-mediastinal nodular shadow. (Cont)



Fig 349 Transverse position radiogram, showing another image of a calcified hydatid cyst (Cont)

filling. The incisura limit of the medial lobe and its branches and fine branchings stand out clearly. The beginning of the filling of the superior lobe and the interruption of the opaque substance at the cyst borderline are observed in these figures

Fig. 351 shows the appearance of the bronchial tree in the final phase of filling. Here the complete filling of the middle lobe is evident; the ventral branches of the superior lobe, however, have their terminations repulsed towards the middle line. Bronchography thus shows indisputably the position of the cyst occupying the superior lobe, even though in the frontal view it seems to occupy the middle lobe. Operation confirmed the diagnosis.



Fig 350 Bronchogram showing initial filling phase and defining the boundary between the middle and upper lobes The detention of the contrast substance is seen in the ventral branch of the upper lobe The arrow points to a calcified cyst in the liver (Cont)



Fig 351 Final filling phase The repulsion of the fine terminal branches of the ventral branch of the upper lobe is clearly evident The arrow indicates the entrance to the upper lobe main bronchus (End)



Fig 352. Frontal position radiogram, bringing into evidence a large circular opacity in the left lung together with emphysema of the base (Cont)



Fig 353 Transverse position radiogram, confirming the circular form and clear outline of normal image (Cont)

Closed Large Diameter Hydatid Cyst

When the cyst has attained a large size it causes gross bronchial displacements and flattening or even complete closure of the bronchial lumen, causing mechanical injury of the tissues ventilated by three bronchial branches.

In the two following cases of this type we may observe the radiologic aspect of the chest by direct radiography as well as bronchography.



FIG 354 Initial filling phase The anterior ascending and descending branches are flattened and displaced (Cont)



FIG 355 During the foliage phase the substance penetrated the anterior ascending branch but not the descending one (End)

The first case is that of an eight year old child who was admitted to the pediatric service of the children's hospital suffering from chest pain, and a cough with expectoration He had no fever, nor had his general health been affected. Direct radiography (Figs 352 and 353) shows a circular area of uniform opacity, with a smooth border clearly defined, situated in the middle field of the left lung. The left base shows emphysema.

The characteristics of this opacity points clearly to the diagnosis of a hydatid cyst, but the definite signs are obtained by bronchographic exploration. As shown in Figs. 354 and 355, the filling of the

bronchial lumen indicates a gross displacement of the bronchial branches and one of them corresponding to the superior lobe, is flattened. Only a filiform lumen remains. This explains the emphysema in the base, as the air enters easily on inspiration when the chest and bronchus expand, but difficulty is encountered on expiration. If the branch becomes completely flattened atelectasis results in the area ventilated by this branch. The bronchographic sign is then of doubtful significance because it is the same one seen in bronchial obstruction by neoplasms as we shall see in the following case.

Gigantic Hydatid Cyst

The hydatid cyst may reach such a size that it can darken almost the whole chest area on the affected side. It is difficult to find a cyst of this size, as before it reaches this great size is either bursts or becomes infected.

When the cyst attains an exceptional volume, the usual radiologic signs disappear and others show up that make the radiologic diagnosis difficult. The clear outline that characterizes the small or medium sized cyst fades out or is found only in some instances. The displacement and flattening out of the bronchus is so extreme that *the lumen is completely blocked, causing interruption of* the opaque substance and forming a lipiodol plug as occurs in carcinoma.

These very misleading images were present on one of Professor T. Villafañe Lastra's patients in the Rawson Hospital in Cordoba. This 35 year old woman complained of coughing, dyspnea, expectoration and left chest pains, becoming progressively more severe.

Direct frontal radiography (Fig. 356) shows an opacity of nearly the whole left chest, only the apex and costodiaphragmatic sinus retaining their normal transparency. The mediastinum shows frank displacement toward the right.

The transverse position radiogram is more illustrative for the opacity occupies only the frontal area of the chest and its posterior borderline is clear, giving the impression that it is the fissure that limits this opacity (Fig. 357). This posterior border bulges frankly toward the back. These images suggest radiologic interlobular pleurisy except for the absence of fever.

Bronchographic exploration showed that the opaque substance was interrupted abruptly at the initiation point of the main trunk of the



FIG 356 Front view image evidencing an almost complete opacity in the left chest The arrows point to the displaced mediastinum and the left boundary of the tumor (Cont)



FIG 357 The same case seen in transverse position, bringing into evidence the anterior position of the opacity with its posterior limit clear and curved (Cont)



FIG 358 Bronchogram of the detention of the opaque substance simulating an endobronchial neoplasm (End.)

superior lobe, giving a typical stop image of an endobronchial tumor (Fig. 358).

As the bacteriologic, parasitologic and cytologic sputum tests all gave negative reactions, Professor Villafañe Lastra decided to tap and obtained a crystalline liquid. The lesion proved to be a closed hydatid cyst of extraordinary size, as the surgical intervention confirmed.

BRONCHOGRAPHY IN RUPTURED CYSTS

A Case of a Small Central Cyst

It is uncommon for a small hydatid cyst to rupture and become infested. This is more likely to occur when the cyst has a diameter of 5 cm. at least, because it is then that the dynamic and biologic conditions favor the freeing of the cyst from the adventitis when it bursts and becomes infected. Notwithstanding its small size, the cyst may burst when those sudden allergic reactions occur in the adventitia which have been studied by A Chifflet (Montevideo).

Even the radiologic interpretation is difficult because in the direct radiogram, the image has no typical characteristics. It may assume the appearance of a round infiltration, a circumscribed abscess, or a neoplasm just forming. Sometimes the sputum test for Koch bacilli is responsible for the finding of hydatid hooks, which are later confirmed by special investigations. This discovery is unexpected as it is not usual to think of the Echinococcus as a possible cause.

An illustrative case is that of a young patient, admitted to the Rawson Hospital for cough and fever of a few days duration with purulent expectoration slightly blood-tinged.

Direct radiography showed an opacity in the middle field of the right chest having the appearance of a nodular infiltration (Fig. 359). In transverse position this image was found to be situated in the superior lobe, in the axillary sublobar area (Fig. 360).

The bronchographic study was done with the object of recording the variations of the bronchial tree that could be caused by such a small pathologic process. It was a scientific curiosity rather than a medical indication. Nevertheless it was this curiosity that led to the correct diagnosis, for it brought clearly to light a ruptured hydatid cyst.

Fig. 361 shows the appearance of the bronchial tree during the initial stage of filling. It is evident that the axillary branch of the



Fig 359 Nodular image of the right middle field, without definite characteristics (Cont)



Fig 360 Transverse position picture showing that the nodular image occupies the projection area of the axillary sub-lobe (Cont)



Fig 361 Clear bronchographic view of the ruptured hydatid cyst Freeing of the membrane and penetration of the iodized oil is evident (Cont)



A B C

FIG. 362 Serial record, during bronchial filling, revealing the characteristics of the filling and clear images of a ruptured hydatid cyst (End)

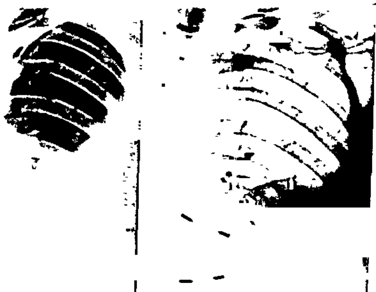


FIG 363. Left chest radiogram showing an opacity with diffuse limits occupying the base (Cont)

FIG 364 Radiogram of the same side of the chest, obtained with a technique for discovering large areas of density. This radiogram reveals a shadow with clear outlines and spherical shape (Cont)

superior lobe communicates with a semi-occupied cavity and that this cavity has a double outline. This is the unmistakable picture of a hydatid cyst freed and ruptured and retaining the germinative membrane.

In Fig. 362 we see in serial form the various aspects assumed by the cyst during the different phases of bronchial filling, which confirm all the observations found in the initial phase. The case was surgically controlled.

Case of a Fissured Cyst with Pleural Reaction

In the following case, we shall see the images formed by the fissuring of the cyst, by the pericystic complication, and by the displacement of the bronchial branches.

Fig 363 shows the appearance of the left chest in which an opaque area having diffuse outlines, and occupying the inferior third of the left lung, is clearly evident.

Radiogram 364 was made with the object of pointing up within the general opacity an opaque area having perfectly clear outlines and spheroidal form Tomography brought this spherical shadow clearly into evidence and revealed a transparency crowning the cyst in its inner quadrant, the phenomenon of air becoming interposed between the germinating and pericystic membrane is known as Morquio, Bonaba and Soto's *pneumopericyst.* In this case the image reproduced in Fig 365 is very clear due to the great amount of air between the germinative membrane and adventitia.



Fig 365 Tomogram in previous case bringing the pneumopericyst into evidence, (Cont)

In many cases, however, the shadow is very small and can be seen only in appropriate incidences.

In this case bronchography was very useful, because it not only brought into evidence the typical bronchial displacement caused by



FIG 366 Initial filling phase Displacement of the inferior lobe branches may be seen (Cont)

the large cysts, but it also permitted localization of the process, a very difficult thing to do in direct radiography, due to the opacity caused by the pleural complication. The bronchogram shown in Fig. 366 was obtained immediately after the filling of the branches of the bronchial tree, and here we are able to identify the branches of the superoanterior lung lobe in a normal position, and those of the inferior lobe completely repulsed and arched, leaving a shadow between the branches that represents the cyst.

Case of Ruptured Cyst with Retention of Germinative Membrane

When the cyst has half emptied through a bronchus direct radiography as well as bronchography can give us very important information. It is even possible to obtain images that reveal unmistakably the presence of the Echinococcus. The diagnostic sign is called by Lagos "sign of the camalote," due to the fact that the germinating membrane floats in the liquid as certain water-plants, called "camalotes," float in the rivers. The sign of the camalote and the pneumopericyst constitute pathognomonic signs of complicated lung hydatid cyst.

Radiogram 367 shows the appearance of the left lung of a patient with purulent expectoration and a slight hemoptysis. An opaque nodule apparently occupies the middle field of the left lung. However, a tomogram (Fig 368) revealed that no such nodule existed and that, in reality, the opacity was constituted by the camalote appearance. Bronchography confirmed the deductions made by tomography The opaque substance found no difficulty in penetrating this cavity, where an intercavitary body, movable with

changes in the position of the chest, was clearly evident. Fig. 369 and 370. This could be nothing more than the germinal membrane retained, as was proved by surgery.

The complete evacuation of the germinal membrane may produce a picture of severe suppuration that obscures the etiology. This was



Fig 367 Part of a direct radiogram showing a nodular shadow in the middle lung field (Cont)



Fig 368 Tomogram clearly showing the presence of a cavity Within the cavity there is a floating hydatid membrane (Cont)

the case in the patient whose direct frontal and transverse radiograms are reproduced in Figs. 371 and 372

This young woman was suffering from a lung suppurative process that had begun in an acute form and that had not improved with any treatment Resistance to treatment is another characteristic of this process

In the direct frontal radiogram we observe a right pericardiac shadow having an increased general opacity at the base of the right lung. In transverse position, a nodular image having a network of outlines and occupying the posterior and basal regions of the lower lobe is evident These images and the patient's clinical history led



Fig 369 Bronchogram of the same case. In the middle of the cavity at the back, a body may be seen that has displaced the contrast substance (Cont)



Fig 370. Transverse position radiogram, revealing the posterior position of the cyst and the intercavity foreign body, or rather the germinal membrane (End)

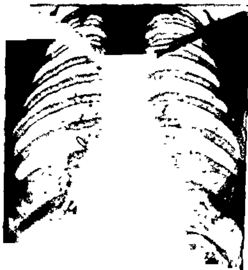


Fig 371. Direct radiogram that shows a right pericardiac and lung base opacity.



Fig 372 Transverse position radiogram showing a nodular opacity *clearly outlined.* (Cont)





Fig 373 Bronchogram and sketch showing displacement of the branches (bronchial dislocation) and bronchiectasis (Cont)



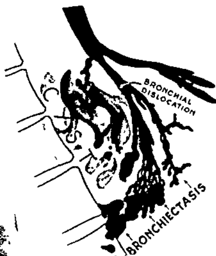


Fig 374 Transverse position bronchogram and sketch The bronchial repulsion, bronchiectasis, and cystic image are evident (End)



Fig 369 Bronchogram of the same case. In the middle of the cavity at the back, a body may be seen that has displaced the contrast substance (Cont)



Fig 370 Transverse position radiogram, revealing the posterior position of the cyst and the intercavity foreign body, or rather the germinal membrane (End)

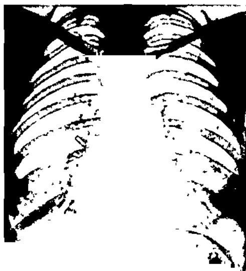


Fig 371. Direct radiogram that shows a right pericardiac and lung base opacity.



Fig 372. Transverse position radiogram showing a nodular opacity clearly outlined. (Cont)



Fig 373. Bronchogram and sketch showing displacement of the branches (bronchial dislocation) and bronchiectasis (Cont)

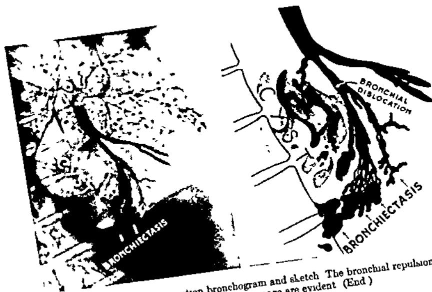


Fig 374 Transverse position bronchogram and sketch The bronchial repulsion, bronchiectasis, and cystic image are evident (End)

us to suspect the hydatid nature of the process but bronchography produced the absolute signs (Figs. 373 and 374). In frontal position the bronchogram shows that the basal trunk and the mediastinal branch have been displaced outward. There is an evident bronchial dislocation which is even better demonstrated in transverse position (Fig. 374).

In addition to this important sign we find a very marked expansion in some of the branches which is characteristic of the hydatid cyst; that is, it causes flattening of the larger bronchi, producing the necessary obstruction for the initiation of the ectasis.

In the same radiograms we may observe irregular opacities in the suspected area which suggest the presence of retained germinative membrane. Lobectomy confirmed the diagnosis.

Case of a Partly Ruptured Cyst with a Suspected Incarcerated Membrane

The incomplete evacuation of the hydatid cyst may indicate a process of desiccation of the residual cavity with imprisonment of the germinative membrane, which finally becomes enclosed in fibrous tissue. Thus the radiologic and anatomopathologic characteristics of the pyocyst that preceded it have disappeared. This process apparently begins after the cyst has cut off the drainage, and therefore exploration may be utilized for the demonstration of the bronchial obstruction.

This record must be indisputable, and therefore multiple technical precautions should be taken

A case which proves the danger of errors when undue value is placed on incomplete radiologic records is that of a patient who stated that she had had a vomica with hydatid characteristics. She had only a slight cough and no expectoration Radiogram 375 shows an opacity in the middle field of the left chest, having a superior wavy outline (sign of the camalote) and crowned by an arch The whole picture is typical of a hydatid cyst half emptied. Fig. 376 reveals the lung in a transverse position, where a similar image is evident, but the wavy image does not follow the horizontal line, apparently due to the desiccation of the cyst, and the membrane becoming fixed in the neighboring tissues. These suppositions were supported by the clinical data.

Bronchial exploration was begun with the patient standing Fig.

377 shows the initial stage of filling and it is noted that the main trunk for the top front lobe as well as that belonging to the lower back lobe are filled. There seems to be a real obstacle to the penetration of the substance into the residual cavity, thus supporting the opinions deduced from clinical examination The continuation of the



Fig 375 Frontal radiogram showing an opacity in the middle lung field, having a wavy upper outline and crowned by a dense arch (Cont)



Fig 376 Transverse image in the same case, revealing similar characteristics (Cont)

bronchographic examination merely confirmed all previous observations as Figs. 378 and 379 prove.

Had we discontinued radiologic examination at this moment—which would not have been objected to—we would have been convinced that the cyst was developing into a membrane incarceration. But our doubts led us to complete the examination by putting the patient into a position that would better favor the penetration of the opaque substance into the upper front lobe, where the cyst was situated. This position, a left lateral decubitus, made it possible to obtain evidence that an ample communication existed between the residual cavity and the bronchial tree Fig. 380 marks the mo-



Fig 377 Initial filling phase The contrast substance cannot penetrate the cavity (Cont)



Fig 378 Image obtained a short time after confirming the difficulty of the contrast substance in the drainage bronchus of the residual cavity. The arrow shows the obstructed bronchus (Cont)



Fig 379 Terminal stage of bronchial filling No communication between the cavity and bronchial tree is seen (Cont)



Fig 380 Radiogram obtained in left lateral decubitus The cavity begins to fill (Cont)

ment with the patient in left lateral decubitus, when the opaque substance began to enter the cavity. The germinative membrane surrounded by iodized oil is clearly shown.

Figs. 381 and 382 correspond to radiograms taken in the standing



Fig 381 Radiogram obtained in standing position. The cavity is half filled with contrast substance Retained membrane is clearly seen (Cont.)



Fig 382 Radiogram obtained in dorsal decubitus, showing the extension of the cavity (End)

position and in dorsal decubitus, respectively. The limits of the cavitary image stand out and the retained germinative membrane is in evidence.

Case of a Cyst with "Incarcerated" Membrane

As we have said previously, anatomically, the incarceration of the germinative membrane of the cyst consists in the retention of this membrane after a partial vomica, and the more or less complete



FIG 383 Direct radiogram showing a clearly outlined opacity of irregular density (Cont)



FIG 384 Tomogram of the same case Retained germinal membrane stands out (Cont)

closure of the bronchi that open up into the cavity. The lung completes this closure by means of a neighbouring fibrosis and vascular neoformation. As a consequence a bronchial delatation is produced.

The clinical picture is usually that of slight hemoptysis, with few or no signs of lung suppuration, and may be mistaken for tuberculosis, but the vomica confirms the diagnosis.

The following case is that of a young man in good general health, seeking for medical advice for a slight hemoptysis. In his clinical history the existence of a small hydatid vomica is recorded. The patient's father has a double lung hydatid cyst.

In Fig. 383 is reproduced the direct radiogram and in Fig. 384 a tomogram of the same case. In the former picture an oblong opacity stands out, having an irregular density and occupying the projection zone corresponding to the right subclavicular area. The limits of this image are quite clear, but it is impossible to determine its exact etiology.

Tomography is conclusive. It shows exactly the depth level of this opacity and allows us to analyze its interior, where we discover unequivocal signs of a retained membrane We must now look for a



Fig 385 Initial filling The secondary branches of the upper lobe are not permeable (Cont)



Fig 386 Late stage The opaque substance has been partially eliminated In some of the tortuous bronchi some iodized oil is seen The impermeability persists (Cont)

bronchial communication with this cystic cavity, and bronchography is the indicated procedure.

Bronchial exploration was carried out with the patient in right lateral decubitus, object being to favor to the utmost the progression of the opaque substance in the superior bronchus. Notwithstanding the fact that the viscosity of the iodized oil was reduced by heating it, and in spite of the most favorable conditions, the oil could not penetrate the superior lobe, as may be seen in Figs 385 and 386. Fig. 385 represents the initial filling stage and Fig 386 a later image after a lapse of several minutes. It is evident that at no time was it possible



Fig 387 Direct radiogram, showing a sub-clavicular residual surgical cavity (Cont)



Fig 388 Tomogram showing a cavity in the right apex in a frontal plane.



Fig 389 Bronchogram confirming the presence of a small cavity in the right sub-clavicular area as observed by radiography and tomography. (End)

to introduce the opaque substance into the channel. Surgery was resorted to and the retained membrane was extracted from an almost desiccated cavity.

Three months later a radiologic examination found the patient to be in very good condition, having no cough or expectoration. Nevertheless, direct radiography showed a small cavity with a clearly defined outline, as may be observed in Fig. 387. Tomography as well as bronchography confirmed the presence of this residual surgical cavity (Figs. 388 and 389). Tomography revealed an oblong cavity situated in the foremost part and a fibrous tracing that continued it forward. Bronchography confirmed the existence of this cavity, which was penetrated by the opaque substance.

Bronchography in Compression and Ectasis Caused by the Hydatid Cyst

As we have already mentioned, the expansive growth of the cyst causes the displacement, the dislocation of the bronchial branches, Piaggio Blanco and Garcia Capurro's sign, and this sign has an extraordinary importance for the discovery of the parasite.

In addition to this displacement, the bronchus undergoes changes in its conformation, dynamism and physiologic function and becomes the seat of inflammatory processes that may be of more importance than the primary cause itself.

Perihydatid chronic bronchitis and its sequela, bronchiectasis, may accompany or follow a hydatid cyst. The former is of less interest as it is a phenomenon directly related to the cyst and may disappear when the cause is eliminated; on the other hand, posthydatid bronchiectasis, as Piaggio Blanco and Garcia Capurro (Montevideo) have repeatedly pointed out, has a more serious prognosis and requires a more vigorous treatment.

The usefulness of bronchography in these hydatid complications has been demonstrated especially by the Uruguayan hydatologists, and nearly all that is known is the fruit of the original investigations carried out by P. A. Barcia, R. Piaggio Blanco, F. Garcia Capurro, N. Caubarrere, Purriel, etc.

The following case demonstrates how the displacement of the bronchus lumen and the lobe atelectasis make the anatomic localization of the cyst difficult. This patient had an incomplete vomica, and her direct radiogram (Fig. 390) shows the unmistakable signs of the



FIG 390 Partly ruptured hydatid cyst The upper arrows show the adventitia, the small middle arrows show the retained membrane Arrow No 1 shows the breast border-line that may be taken as part of the cyst Which lobe does it occupy? (Cont)



FIG 391 Transverse position radiogram, showing the sign of the camalote but not the exact situation of the cyst (Cont)



FIG 392 Tomogram showing atelectasis in the middle lobe and the incisuritis of the median incisura. (Cont)

presence of the retained membrane. In this radiogram it is very difficult to make an exact localization, as there are signs that support the possibility of its being in any of the three lobes.

In transverse position (Fig. 391) the radiogram confirms the signs of the camalote, but it does not indicate in which lobe the parasite has developed. The images tend to show that the middle lobe has been affected and this supposition has been supported by tomography



Fig 393 Initial filling phase The middle lobe branches are displaced downward and inward. (Cont)



Fig 394 Intermediate filling phase The contrast substance has progressed in a normal manner in the inferior lobe, but has been detained in the branches of the middle lobe, more so in the upper inner branch (Cont)

(Fig. 392), where incisuritis and the atelectasis of the medial lobe are evident.

In these circumstances only the visualization of the bronchial tree can definitely reveal the state of the tissues neighboring the cyst, the existence or non-existence of the atelectasis, and the precise localization of the process.

Serial bronchography is the indicated procedure for obtaining a correct diagnosis. Figs. 393 and 394 represent the initiation of the

bronchial filling. The cyst has displaced the branches of the middle lobe inwardly. In the two successive plates the opaque substance has progressed rapidly in the branches of the lower lobe, where foliage is beginning to form. In the middle lobe on the other hand, the opaque oil has progressed only as far as the medium branchings, and only in the lower posterior branch, while in the upper front lobe the opaque substance has been detained.

The transverse position radiogram (Fig. 395) brings into evidence



Fig 395 Radiogram in transverse position bringing into evidence the flattening of the bronchial branches of the middle lobe and their downward repulsion Lower lobe has normal bronchographic characteristics (Cont)



Fig 396 The opaque substance has filled the upper lobe bronchus and has partially penetrated the cyst (Cont)

these dynamic and anatomic alterations that were found in the first frontal radiograms. The branches of the middle lobe are compressed against each other, no fine branches nor foliage have been formed, which, however, has happened in the inferior lobe. The branches of the middle lobe are below the cyst and surround its lower limit. Furthermore, the opaque substance has not penetrated the cystic cavity. All this shows that the cyst is localized in the upper lobe and communicates with the bronchial branches of this lobe.

Later radiograms confirm this conclusion, as by inclining the position of the patient still more and introducing a greater quantity of the opaque substance, we manage to fill the main bronchus of the superior lobe and get the iodized oil to penetrate the interior of the cyst. Fig. 396 shows the bronchographic picture at this moment, which is confused, due to numerous images shadowing each other. Nevertheless, as the arrows point out, we may see the main bronchus

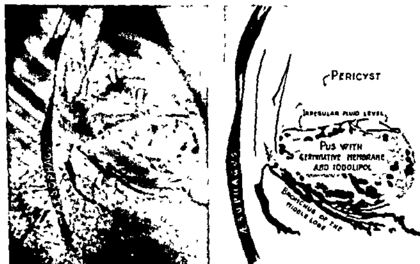


Fig 397 Transverse position radiogram and sketch showing the opaque substance within the cystic cavity The middle lobe branches retain the characteristics recorded in the first radiogram (Cont)

of the upper lobe and a little of the opaque substance at the bottom of the cyst.

The plate in transverse position (Fig 397) shows more clearly the presence of the opaque substance inside the cystic cavity. The arrows indicate the superior limit of the cyst and the retained membrane The patient has swallowed the opaque substance after a coughing fit and this is the reason for the registering of the esophagus.

Surgery confirmed all the conclusions obtained from this bronchographic study.

Two months postoperatively the patient was again explored and the lung parenchyma and the bronchial tree still showed residual

surgical manifestations as well as those due to middle lobe atelectasis. The residual cavity was reduced to a fourth of the size of the cyst before operation and communicated amply with the anterior bronchus. The branches of the middle lobe were not permeable (Figs. 398 and 399), allowing the formation of normal foliage. The calibre of the sub-branchings was nevertheless irregular and dynamic properties were diminished. The bronchographic picture indicated that the



Fig 398 Bronchographic aspect in the late filling phase The residual cavity and middle lobe branches (see arrows) that absorb the contrast substance slowly are evident (Cont)



Fig 399 Transverse position image Here it is evident that the middle lobe branches have produced foliage The arrow shows part of this foliage and the incisural limit. (Cont)

middle lobe would in time attain its normal bronchographic aspect and dynamic characteristics.

Six months postoperatively examination showed how the healing of the residual cavity had caused displacement of the middle lobe bronchi in the opposite direction to those that had existed before the cyst was removed. Before operation the main trunk and the principal branches had been displaced downward by the growth of the cyst, and a flattening of the lobe occurred causing an atelectasis. Now, six



Fig 400 Transverse position radiogram showing residual cavity (Cont)



Fig 401 Tomogram of the same case Observe the thick portions that converge toward the cavity (Cont)

months after operation, the retraction process has caused a deviation in the opposite direction, with a frank bedding of the main branch of the medial lobe. Figs 400 and 401, in transverse position, represent



Fig 402 Initiation of bronchial filling, showing the sudden bending of the main branch of the middle lobe



Fig 403 Late image of bronchial filling Here the deviation undergone by the main bronchus is confirmed and foliage with normal characteristics is evident (End)

direct radiography and tomography, respectively, showing in both the residual cavity and the presence of thick fibrous bands that converge toward the cavity. Figs. 402 and 403 show that the bronchial branches of the medial lobe are drawn toward the superior lobe where the residual cavity is found. Nevertheless, normal foliage has formed.

Residual Cavity and Posthydatid Bronchiectasis

Sometimes a patient who has undergone an operation for hydatid cyst with removal of the germinal membrane may have postoperative



Fig 404 Frontal radiogram. No lesion of the lung parenchyma is evident here as the disease is in the retrocardiac region. (Cont.)



Fig 405 Frontal position tomogram showing retrocardiac cavitary lesion (Cont.)

reactions more serious than the primary process itself. This is because of the presence of perihydatid bronchiectasis and of residual cavities of varying size, in exceptional cases having a diameter of 4 or 5 cm. Clinically and radiographically the picture may simulate that of tuberculosis. This clinical picture is not constant Periods of quiescence and exacerbations alternate as shown in the radiologic images.

For bringing these residual cavities and bronchiectasis to light we have found bronchography very useful. It often discovers unsuspected lesions not duly appreciated in direct radiography. The following case is an example. The patient periodically suffered from hemoptysis and bronchorrhea. Her previous history records an incomplete

hydatid vomica, the membrane of which was expelled in portions during a prolonged suppurative cycle.

For more than a year she had had periods of improvement alternating with periods of retrogression, characterized by coughing, hemoptysis and bronchorrhea Her case had been reviewed by several doctors who had limited themselves to a clinical examination and a frontal radiogram and had been unable to discover the cause of the



Fig 406 Frontal radiogram bringing into view a large cavity in the inferior lobe of the left lung with pericavitary bronchiectasis (Cont)

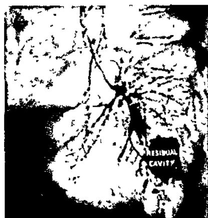


Fig 407 Bronchography in almost transverse position, showing the posterior location of the residual hydatid cavity (End)

trouble. During one of the exacerbations the patient presented herself at the tuberculosis dispensary in the Rawson Hospital in Cordoba, for examination Sputum examination revealed no evidence of Koch bacilli Radioscopy brought into evidence an area of sclerosis in the left base, in the retrocardiac posterior region. Frontal radiography showed no lesion, as it was hidden behind the heart shadow (Fig 404) A transverse radiogram revealed a sclerotic zone in the lower region, projecting over the spinal column. Tomography, however, clearly showed the presence of a retrocardiac ulceration, as is seen in Fig. 405.

Bronchographic study was conclusive as it confirmed the presence of ulceration and brought into evidence the changes in the neighbouring bronchial branches consisting in pericavitary bronchiectasis.

Figs. 406 and 407 represent the bronchograms obtained in frontal and transverse positions.

Case of a Ruptured Cyst Leaving No Apparent Residual Cavity

Sometimes the biologic, clinical and radiologic evidence of the presence of the Echinococcus in the lung is uncertain, thus making the diagnosis difficult.

This is illustrated in the following case represented by Fig. 408 in



Fig 408 Direct radiogram revealing a dense opacity with clear outlines, occupying the apex of the left lung The etiology of this was not clear at first. (Cont)

which a well limited opacity of the apex of the left lung is observed. This young man had a cough and a slight mucopurulent expectoration that was exceptionally hemoptoic. No Koch bacilli were found in the sputum, nor were the biologic reactions for hydatidosis positive. The patient returned after several months because, as he stated, he had had fits of vomiting containing salty water and some white membranes. A new radiogram was obtained, showing the reduction in the opacity of the upper left lobe. (Fig. 409). A soft veil

was seen in that area crossed by traces that seemed to correspond to vascular and other fibrous or lymphatic elements. No residual cavity was observed, although the expectoration indicated the presence of one. The existence of this cavity could confirm the diagnosis of hydatid cyst, according to the patient's report, and for that reason a contrast exploration was carried out.

The introduction of the contrast substance offered serious diffi-

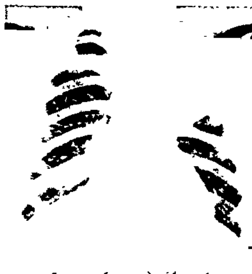


FIG 409 Radiogram obtained after vomiting A slight opacity persists in the left apex There is no evidence of a cavity. (Cont)



FIG 410 Bronchial image in standing position No residual cavity is evident (Cont)

culties, in filling the upper left lobe, and as the various plates obtained in several positions show, only a suitable position of the patient *made it possible to obtain convincing conclusions.*

The first images were obtained with the patient in a straight supine and left inclining position. These images reproduced in Figs. 410 and 411 do not allow us to affirm positively the presence of any residual cavity; although certain elements suggest its existence.

The most appropriate positions to fill in the apex are the left lateral decubitus and the ventral left lateral decubitus. It was in those positions that we obtained the radiograms which showed the existence

of the residual cavity without a retained germinative membrane, and dilatation of the neighbouring bronchi, as Figs. 412, 413 and 414 reveal.

This case proves the importance of bronchographic study for the discovering of non-apparent cavities and the necessity for correct technical conditions and suitable position of the patient for the



FIG 411 Standing position radiogram with chest in oblique position This makes us suspect the presence of a cavity although it is not shown (Cont)



FIG 412 Radiogram obtained in left lateral decubitus The filling of the residual cavity of the apex has begun (Cont)

contrast substance really to penetrate the affected region. If these rules are not strictly observed errors in diagnosis may occur, resulting in ineffective or improper treatment.

Posthydatid Bronchiectasis

As we have already shown, bronchiectasis may occur before the hydatid cyst is evacuated, or it may follow the evacuation together with the cavitary sequela or with the incarcerated membrane enclosed in sclerotic tissue that shows the site of the old cyst. It is in this type of late posthydatid bronchiectasis that the prognosis is grave



Fig 413 Radiogram in ventral decubitus The cavity and neighboring bronchiectasis are seen (Cont)



Fig 414 Radiogram in left lateral decubitus and transverse position



Fig 415 Direct radiogram showing a fibrotic area in the left middle lung field (Cont)



Fig 416 Initiation of filling Forward descending branch fills irregularly and does not give out fine branchings (Cont)



Fig 417. Intermediate filling phase The characteristics of bronchiectasis are intensified in contrast to the normal branches



Fig 418 Final filling phase, obtained in transverse position The bronchiectasis of the lingula lobe becomes evident (End)

as the patient's general health is impaired by continued hemoptysis and reinfections, and lobectomy is the only effective treatment

Fig. 415 represents a chest radiogram of one of these patients who had a hydatid cyst. She vomited the contents of the cyst and apparently recovered. A year later, however, she again began to have some expectoration and hemotysis, sometimes severe.

Direct radiograph revealed only a slight sclerosis in the medial lobe of the left lung. Bronchography brought into evidence gross lesions in the anterior descending branch of the upper lobe, characterized by

the expansion of the main branch and the small afferent branches Figs. 416, 417 and 418 representing the successive phases of filling show all the characteristics of posthydatid bronchiectasis.

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CHAPTER XIII

Bronchography in Lung Suppuration

Lung suppurations present various clinical and radiologic aspects. It is well known that these processes may become complications of other diseases which have initiated the lung picture—hydatid cyst for instance—or they may constitute the primary cause of the disease.

Suppuration may appear in single or in multiple pre-existing cavities of varying sizes, of these cavities many appear or enlarge after suppuration begins, either alone or in colonies. So it happens that air cysts or emphysema vesicles suppurates and abscess like bronchiectasis.

Lung suppuration may also become manifest as a pyogenic process developing in a previously healthy lung, and transported to the lung by the blood stream or the airways The process may be localized or diffused Bronchography is especially indicated in the localized form, less frequently in the diffuse form

Varied bronchographic images may be caused by lung suppuration, and we still remember the discussions as to whether the lung cavities due to abscesses fill or do not fill with the contrast substance. This discussion can be explained only by ignorance of the clinical and radiologic problem.

The anatomic forms of lung destruction are conditioned by several factors that *modify local conditions, especially conformation and* dynamism, and this explains why the contrast substance penetrates sometimes and sometimes fails to do so in similar cases. To these local factors we must add technical errors that may lead to erroneous conclusions. Among those we must specially mention the viscosity of the contrast substance used, the position of the patient during exploration and the preparation of the region to be explored.

The viscosity of the contrast medium conditions the success of the exploration. *Opaque oils* introduced *cold* into the airways, have a very high viscosity, and for this reason adhere to the walls of the bronchi and will not penetrate narrow or tortuous canals. In cases of lung suppuration, the oil should be introduced at the maximum

heat toleration and those oils having lower viscosity are preferable *even though they do not produce a very high degree of opacity. It* might be wise to use less viscous opaque substances, such as Uroselectan B. or Perabrodil.

The *position* of the chest at the time of the exploration is of very great importance, for the opaque substance, on account of its high density, tends to follow the laws of gravity. In exploring patients with lung suppuration we have sometimes believed that the contrast substance would not penetrate, but when the patient was placed in a correct position and an appropriate contrast substance was used, the penetration of the affected area was successful.

Preparation of the patient consists principally in the cleaning of the region to be explored. There is nothing more useful for this than bronchoaspiration and bronchial lavage previous to and immediately following bronchography.

Following bronchoaspiration, one is tempted to introduce the opaque substance through the aspiration tube *This error is the major cause of failures and should not be committed* A patient with the bronchoscope in place is not in a condition to be moved and placed in the most convenient position for bronchography. We must emphasize that the bronchoscopic tube must be extracted before the patient is placed in the appropriate radiologic positions for the introduction of the opaque substance. If the patient is *adequately prepared*, placed *in a correct position* and a contrast *substance of light viscosity* is *used*, lung abscesses and all the other lung cavitary suppurations are filled in with the contrast substance.

Clearly Outlined Circumscribed Abscess

In the direct radiogram, the lung abscess does not present a characteristic picture. In general it is an opacity not having a uniform density, having no precise limits, situated in the most diverse lung areas.

In Fig. 419 the affected zone, indicated by arrows, appears as an opacity of the left middle field, having irregular density and uncertain limits.

Fig. 420 shows the tomographic aspect of the same lesion. The clear zones stand out more clearly.

Tomography brings out the clear outline of the process, as the direct radiogram failed to do The tomographic picture favored the

diagnosis of suppurated hydatid cyst, but neither the clinical picture, the laboratory tests, nor the course of the disease supported this opinion. Rather they inclined toward the diagnosis of circumscribed abscess. Bronchograph was decisive, for it revealed the presence of a tortuous cavity difficult to fill, and no alterations were seen in the neighbouring bronchial branches.

Fig. 421 shows the initial filling phase (frontal view) of the bron-



Fig 419 Left lung middle field opacity (Cont)



Fig 420 Tomogram of the same case A clearly defined area of opacity of irregular density is seen. (Cont)

chial tree. No changes are observed in the branches of the lower lobe. The upper lobe branches show changes in the outlines and thickness of the forward descending branch (branch of the lingula lobe).

Fig. 422 is a late bronchographic image showing the uniform formation of the foliage in the whole lung, except in the suspected region shown in the first bronchogram, where we found a collection of cavities partially filled by the contrast substance.

Paraincisural Circumscribed Abscess

The following is a case of circumscribed abscess in a man over 50 years old. The clinical and bacteriologic pictures were typical

Fig. 423 is a direct radiogram of the right chest showing a clearly outlined area of opacity in the right lower portion, limited by the horizontal incisural plane. In the superior portion the outline is blurred. The opaque area has a uniform tone, and extends from the



Fig. 421. Initial filling phase. Changes in the upper lobe and forward descending branch are evident. (Cont.)



Fig. 422 Final filling phase in which several cavities in the lingula lobe are seen (End.)

mediastinal border to the lateral wall. A careful study of the shadows (Fig 424) shows that this opacity enclosed multiple clear circular areas.

Bronchogram 425 represents the early filling of the airways Here it is evident that the branches corresponding to the upper lobe are thickened, have an irregular outline and filling is not uniform The anterior branch of the upper lobe is destroyed and communicated by a tortuous course with several cavities These images are still more demonstrative in Fig. 426 which corresponds to a late image. The

bronchogram shows the permeability of the *apical and axillary* branches and the penetration of the contrast substances into some of the cavities that communicate with the anterior and axillary branches.

The images obtained in this case are typical and a more complete filling could not be secured by any technical device.



Fig 423 Direct radiogram showing well defined area of uniform opacity of the right middle lung field (Cont)



Fig 424. Radiogram of the affected area, showing the presence of light areas in the opacity (Cont)

Lobe Abscess

Lung suppurations are not always limited to small areas as in the reported cases. The process sometimes occupies an entire lobe, and infrequently may exceed the incisural limits and invade other lobes.

In these cases, it is difficult to differentiate the process from lung cancer Bronchography alone gives us precise data to establish the diagnosis

Fig. 427 represents the right chest in the case of a patient in whom

a lung abscess had been diagnosed. It was suspected, however, that a concomitant bronchial neoplasm was present causing atelectasis of the lobe with secondary suppuration.

Bronchographic study may be decisive in these cases, for when a neoplasm has obstructed the ventilation trunk of the lobe, obstruction then causes a complete stoppage of the opaque substance.



Fig 425 Initial filling stages Complete deformity of the anterior branch of the upper lobe (Cont)



Fig 426 Late filling stage, revealing the normal appearance of the axillary and apical branches of the upper lobe and the microcavities neighboring the anterior branch (End)

In this case the opaque substance found no difficulty in penetrating the upper lobe, it even managed to fill the initiation of the secondary branches, as may be seen in Fig. 428 In the first branches there are signs of extensive suppuration, which disfigures the outlines of the columns No foliage has been formed that would reveal a process that affects exclusively the small branches and the acini.

Excavated Abscess

The direct radiogram may not provide conclusive data regarding

the state of the lung parenchyma affected by the suppurating process. The different opacities that surround an excavation *sometimes* cause a confusing image that neither permits us *to affirm nor to deny* the presence of a destructive process.

Other radiologic procedures, notably *tomography, may collaborate* effectively to define this interpretation. Bronchography provides



Fig 427 Right chest radiogram, showing a dense opacity in the whole of the upper field. (Cont)



Fig 428 Bronchogram of the same case No obstruction is present in the bronchial trunk Evidences of suppuration are seen in the small branches

facilities for confirming *or denying the existence of the excavation* and brings to light the characteristics of the bronchial tree that ventilates the affected area, enabling us to arrive at diagnostic and *topographical conclusions* as well as *providing* indications for treatment.

Fig. 429 is a direct radiogram of a *patient* with a lung abscess. From this picture as well as in the transverse position (Fig. 430),

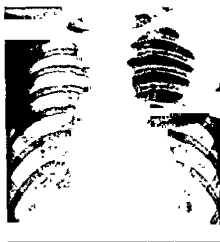


Fig 429 Frontal radiogram revealing an opacity in the middle field of the left lung (Cont)



Fig 430 Transverse position image showing the opacity previously pointed out in the upper lobe In both positions, no cavities are observed (Cont)

it is not possible to obtain any other data than the presence of a lung condensation process

Serial bronchial exploration brought into evidence a large cavity, not suspected in direct radiograms.



Fig 431 A, B, and C, are three aspects of the serial record of the filling of the upper lobe The presence of a cavity communicating with the axillary branch of the upper lobe is evident (Cont)

As seen in Fig. 431, the opaque substance penetrated a cavity communicating with the axillary branch of the upper lobe.

The radiogram in transverse position (Fig. 432) showed that the cavity was occupying a para-incisural position.

Hydro-Air Cavity

When the suppurative process has destroyed a large portion of the lung parenchyma in an area ventilated by a medium size bronchus, a hydro-air cavity is produced that is easily filled by the contrast substance. In these cases bronchography merely confirms the presence of a cavity that had already been diagnosed by direct radiography or by tomography, but bronchography is superior to these means of exploration since it provides information regarding the bronchi neighboring the cavity and reveals other smaller cavities. This information is important for it permits us to differentiate the cavities due to primary suppurations of the lung from pre-existing suppurated cavities, as the air cyst or residual cavity of the evacuated *hydatid* cyst which was discussed in Chapter XII.



Fig. 432 Bronchogram in *transverse* position The cavity occupies a paraincisural position. (End)

If the case is one of suppurated air cyst co-existing with the filling of the cavity, we find bronchial malformations in the vicinity, a scarcity of secondary branching, and absence of foliage.

When the case is one of a *hydatid* cyst residual cavity, there frequently exists a pericavitary bronchiectasis so prominent that it may be taken as a pathognomonic sign, as Piaggio Blanco and Garcia Capurro (Montevideo), have emphasized.

Fig. 433 is a bronchographic picture of the lung of one of these patients who suffered from a lung abscess for many months. In this radiogram, the opaque substance has easily penetrated the cavity notwithstanding its marginal and apical positions. The neighboring

branches are altered only by the presence of pus in their interior, but no other modifications in the calibre are found that might lead to a diagnosis of residual hydatid cyst cavity or a suppurated air cavity. Fig. 434, is a radiogram obtained in standing position, where the level formed by the opaque substance is clearly evident. The evacuation



Fig 433 Bronchogram showing a large cavity occupying the apical region Obtained in right lateral decubitus (Cont)



Fig 434 The same case in standing position, showing the typical level and the image of the bronchi in relief (End)

of one of the air channels permits us to observe the outlines, where it is now seen that the lesions are in the walls and that the alterations seen in the first bronchogram were due to the purulent contents.

Operated Abscess

After an operation for a lung abscess some doubt may exist as to the completeness of healing. The information provided by direct radiography is usually of doubtful value, for rib neo-formations, fibrous tissue, and deformities of the area make it impossible to arrive at a conclusion as to the existence or non-existence of cavities. Neither does tomography give a conclusive picture of the lung condition in this area. If in addition, the clinical picture is not decisive, there remains no other possibility except contrast exploration

As seen in Fig. 431, the opaque substance penetra communicating with the axillary branch of the upper lol

The radiogram in transverse position (Fig. 432) sho cavity was occupying a para-incisural position.

Hydro-Air Cavity

When the suppurative process has destroyed a large p lung parenchyma ventilated by a n bronchus, a hydro-a produced that is eas the contrast substan cases bronchography firms the presence of had already been d direct radiography o raphy, but bronchog perior to these mea tion since it provid regarding the bronc the cavity and smaller cavities. tion is important to differentiate to primary sup lung from pre-e cavities, as the cavity of the cyst which was discussed in Chapter XII.



FIG. 432 Bronchogram in transverse position The cavity occupies a paraincisural position. (End)

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Fig. 433 is a bronchographic pictur patients who suffered from a lung al radiogram, the opaque substance notwithstanding its marginal and



FIG 436 Initial stage in exploration, showing the filling of the lower lobe before the appearance of any cavity (Cont)



FIG 437 The opaque medium begins to penetrate a cavity (Cont)



FIG 438 The cavity is completely filled with the opaque medium. Changes in the large neighboring trunks are observed (End)

through the bronchus, much more useful than is the introduction of the opaque substance through the course of the fistula.

It is in cases of this type that special precautions should be taken if the procedure is to be successful.

Fig. 435 is a radiogram of the right chest of a patient who had been operated upon some months previously by Dr. Langer for an abscess of the posterior apex of the lower lobe. As the patient did not expectorate nor had she any sign of pus retention, it was believed that the abscess was cured. However, it was decided to confirm this by a bronchographic study. From this study it was concluded that cavities communicating with the bronchus did not exist, and that therefore healing had been effected. Nevertheless, some days after the exploration, the apparently closed thoracic fistula, opened, giving an outlet to pus. For this reason the doctor asked us to explore his patient with our technique, for he doubted that the first exploration had revealed the real state of the lung. It was then that we obtained the direct radiogram in Fig. 435, and we explored the bronchial tree under radioscopic control.



FIG 435 Direct radiogram taken several months after an operation for a lung abscess Some of the oil is still present in the lower half of the lung (Cont)

In order that the oil might penetrate into the first dorsal branch, which immediately revealed changes in conformation and calibre, it was essential to place the patient in dorsal decubitus and in right anterior oblique.

Fig. 436 shows this first phase in filling. The opaque substance has *occupied the middle and lower lobes, and as yet,* has not filled any cavity. The introduction of a larger quantity of contrast substance with the patient in the dorsal decubitus position, however, revealed a *large cavity* that had not been suspected.

In Figs. 437 and 438 the profound bronchial alterations are clearly shown.

Bronchogram 439 shows us the appearance of the bronchial tree in a case of multiple suppuration of the lung, in which destruction of the parenchyma is the predominating process, neither the architecture nor the conformation of the bronchial branches being affected.

Fig. 440 is a direct radiogram of the left chest of a patient who has had a purulent expectoration for several months. His general health



Fig 441 Bronchogram in the preceding case, showing the complete deformity of the bronchial branches of the entire left lung (Cont)



Fig 442 Picture obtained at the moment hemoptysis occurred and during which the opaque medium mixed with the blood

has been greatly impaired and the clinical history followed during the past month indicates that lung destruction is extensive The direct radiogram reveals a dense and uniform opacity of the left lung base, continued upward by a spotty opacity In the upper regions small nodules are observed.

Contrast exploration (Fig. 441) revealed extensive destruction of the bronchial walls, affecting equally left lobes and all their branches. In the lower area the pus was detained in large sacs where it mixed with the opaque medium. While this exploration was being carried out, the patient had a severe hemorrhage and before she

Multiple or Diffuse Suppuration

Diffuse lung processes may become manifest as a complication of a generalized bronchiectasis whether acquired or congenital. The majority of these cases have been studied by us in connection with broncho-pulmonary congenital malformations, for it is common to find diffuse suppuration under these conditions. Sometimes suppuration affects the bronchi and parenchyma equally; manifestations of



FIG 439 Bronchogram of a patient with multiple suppurating lesions in the lung. (End)



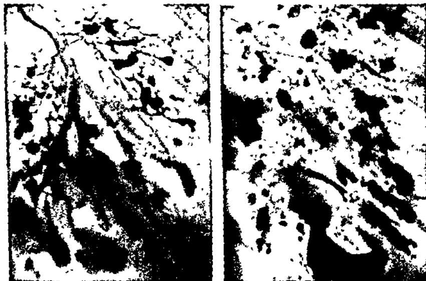
FIG 440 Left chest radiogram, showing the opacity of the lung base (Cont)

lung destruction then appear simultaneously with those of bronchial destruction Finally, in a third pathologic picture, the destruction of the lung parenchyma predominates, the bronchial lesions being minimum or secondary.

Clinically, even with the aid of direct radiography, it is difficult and often impossible to differentiate these pathologic pictures, and their identification is possible only after the introduction of the opaque substance into the airways.

Bronchogram 439 shows us the appearance of the bronchial tree in a case of multiple suppuration of the lung, in which destruction of the parenchyma is the predominating process, neither the architecture nor the conformation of the bronchial branches being affected

Fig. 440 is a direct radiogram of the left chest of a patient who has had a purulent expectoration for several months. His general health



[illegible] (Cont.)

Fig 442 Picture obtained at the moment hemoptysis occurred and during which the opaque medium mixed with the blood

has been greatly impaired and the clinical history followed during the past month indicates that lung destruction is extensive The direct radiogram reveals a dense and uniform opacity of the left lung base, continued upward by a spotty opacity In the upper regions small nodules are observed.

Contrast exploration (Fig. 441) revealed extensive destruction of the bronchial walls, affecting equally left lobes and all their branches In the lower area the pus was detained in large sacs where it mixed with the opaque medium. While this exploration was being carried out, the patient had a severe hemorrhage and before she

expectorated blood we had an opportunity for radioscopic observation of how the image was modified, for the opaque medium was drawn out by a cause that we did not discover at that moment. Fig 442 shows the picture of the change that occurred during the hemorrhage. It will be observed that the opaque medium mixes in part with the transparent blood and that the medium is retained only in the large sacs. This accident is not a common one, and although medical procedures might be responsible in this case, it should be mentioned that the patient had had similar hemorrhages on other occasions.

Residual Cavities

Restoration of the tissue in an area that has been abscessed is not always complete. In most instances the bronchi of the affected area

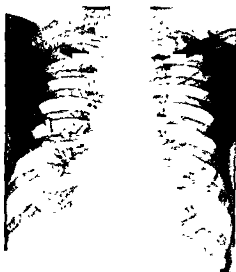


Fig. 443 Direct image showing the trabeculae and condensation of the middle area of the right lung. The pericardium is retracted toward the lesion (Cont)



Fig 444 Tomogram showing the central part of the affected area constituting multiple cavities (Cont)

are expanded and communicate with small cavities with fibrous walls. It is this bronchiectasis and these residual cavities that periodically alarm the patient with recurring purulent expectoration or with slight hemoptysis as this area is abundantly supplied with blood vessels.

Direct radiography is not very useful for discovering these areas for if it does tell us in which lung or in what region we may find the cicatricial remains of the abscess, it gives us little information about the characteristics of the scar. It remains for bronchography to put us on the watch for extensive unsuspected lesions.

The direct radiogram in Fig. 443 is that of a patient with a history



FIG 445 Frontal bronchogram showing the branches of the middle lobe expanded and the cavities with which they communicate (Cont)



FIG 446 Transverse position bronchogram, showing the location of the lesion and its relation to the other lobes (End)

of a periodically reactivated lung abscess. In the middle field of the right lung, a trabeculated condensation of the parenchyma is evident The other lung areas are normal.

Tomography provides more information than does the direct radiogram. In Fig. 444, the cavities and incisural limits stand out clearly, as well as the traction of the paricardium toward the lesion.

Nevertheless, *bronchography* is necessary to demonstrate clearly the morphologic characteristics of this area As may be observed in radiograms 445 and 446, the opaque medium penetrates the bronchial branches corresponding to the middle lobe, which are expanded, and these in their turn communicate with residual cavities

The process affects mainly the antero-superior sub-branch for the

lower posterior one partly retained its normal characteristics. In transverse position (Fig. 446), the location of the process and its features are very clearly evident.

Bronchographic Control of the Healing Process

Bronchography is useful to ascertain the condition of the bronchial system and the lung parenchyma after it has been subjected to various types of treatment.

It is well known that direct radiography does not serve this purpose and that destructive lesions of the parenchyma may exist without any radiologic expression.

Although there are no absolute signs which demonstrate bronchographically *the healing of a disease process*, there are, however, a group of relatively reliable signs that lead us to suspect that healing has occurred or at least that we are making progress in that direction. We are guided here, as in the digestive tract when radiologically studying the course of a gastric ulcer where also we may not be able to obtain absolute signs, but the characteristics of the area, together with the clinical condition of the patient, allow us to make correct deductions concerning the condition of the affected area.

Case 1. The following case illustrates how the condition of the lung may be studied bronchographically. The patient, 44 years old, was admitted on the surgical service of Professor J M Allende, with the clinical and radiologic picture of a post-influenza left superior lobe abscess

Direct radiogram (Fig 447) shows an opacity of the upper areas of the left lung and an ulceration in the outer infra-clavicular field.

The presence of other ulcerations is suspected, and for this reason various tomographic planes are obtained, one of which (Fig. 448) reveals two large ulcers surrounded by small ulcers. The quantity and the putrid odor of the expectoration, the bacteriologic findings, the auscultation signs and the radiologic images all point to a case of chronic lung ulcer. The characteristics of the lesion indicated a grave prognosis, particularly since the symptoms had been present for six months.

Bronchography revealed the usual signs of lung suppurations: obstruction of small branches, irregularity in the calibre, incomplete filling, small [illegible] of fine bronchioles and

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thermocauterization, Dr. Lanza Castelli, bronchoscopist, [illegible] out bronchoaspiration and bronchial lavage with sulfathiozole solution Various sulfa drugs were also given by mouth and the patient later received injections



FIG 447 Direct radiogram showing ulceration of the lung and the opacity of the upper lung field (Cont)

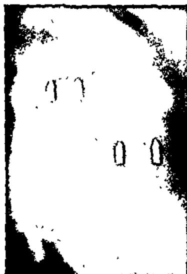


FIG 448 Tomogram Middle chest plane, where two large ulcerations and other small ones surrounding it are observed (Cont)



FIG. 449. Left lateral decubitus bronchogram. The arrow points to the liquid level in the cavity. (Cont)



FIG 450 Direct radiogram obtained after six months treatment The old lesions are not seen (Cont)



FIG 451 Tomogram obtained after treatment No destructive lesions of the parenchyma are observed. (Cont)



FIG. 452. Bronchogram obtained after six months treatment. The bronchial branches reveal changes in conformation but the obstructive images in the air channel are few. (End)

of sulfarsphenamine. After five months the patient's condition changed

showed a lung picture very nearly normal. The previous opacity had entirely disappeared, no ulcerations were observed and only a thickened reticulum indicated that lung lesions had been present in this area. Neither did tomography demonstrate any lesions Fig 451 represents the middle plane, where lesions were found previously and where only an abnormal broncho-vascular architecture is now evident Contrast exploration showed an abnormal aspect of the bronchial tree, but not like that obtained previous to the medical treatment As may be seen in Fig 452, the opaque medium has penetrated the bronchial branchings of irregular calibre and outlines that end up in small pools or ectasis In the area previously affected a badly distributed foliage is outstanding There are few signs of suppuration and the secretions have not obstructed the air channels

The clinical course and the radiologic evidence, direct and bronchographic, indicate an extraordinary therapeutic success Nevertheless the ectasis discovered in the bronchogram should warn the physician that this may constitute the starting point for the flaring up of the old process, and for that reason, medical treatment must be insisted upon

Case 2. This case not only permits us to evaluate the importance of the contrast exploration method for the investigation of the anatomic bronchopulmonary condition, but it also shows us the great possibility of tissue repair that exists in this part of the organism

This patient is 40 years old, and presents a picture of chronic lung abscess of post-influenza origin, with a bronchorrhea of more than 500 Grams daily having an extremely putrid odor

Direct radiography (Fig 453) reveals a dense opacity of the right base, having very clear superior limits



Fig 453 Direct radiogram showing opacity of the right base with a clear upper border (Cont)

Contrast exploration revealed the presence of extensive bronchopulmonary anatomic changes in the lower lobe, especially in the sub-lobe ventilated by the first dorsal.

In Figs 454 and 455 we observe that in the affected zone the bronchial branches have the characteristics that denote a suppurative process, and they communicate with large cavities situated in the posterior apex of the lower lobe

This patient, like the previous one, was treated by Dr Castelli, who



Fig 454 Frontal position image, in which a large cavity and profound changes in the bronchial branches are seen (Cont)



Fig 455 Transverse position image, showing the posterior position of the cavity (Cont)

carried out bronchoaspiration and bronchial lavage with sulfa solutions and directed the general medical treatment.

Six months later another bronchial exploration found the general condition of the patient improved and the bronchorrhea had almost completely disappeared. At the time bronchography revealed a fundamental change in the bronchopulmonary condition The great cavity had disappeared; the bronchial branches acquired a more nearly normal appearance and only a few terminal ampullar ectases of the branches were evident (Figs 456 and 457).

Bronchography in Broncho-Thoracic Fistula

The presence of a communication between the bronchus and the exterior through the lung parenchyma, the pleura and the chest wall

can be demonstrated by various methods, but only contrast exploration can give us a graphic picture of the course of the fistula or of the bronchus or the starting point of the fistula. This last item is of great importance in directing and carrying out the treatment.

An illustrative case that shows the possibilities of the contrast method in broncho-thoracic fistula is demonstrated in Fig 458.



FIG 456 Bronchogram taken six months after treatment The bronchial tree shows fewer changes Some ampullar ectasis is evident (Cont)



FIG 457 Transverse position image (End)

Here the opaque medium, after penetrating the collapsed lung, has continued along a fistulous course that starts from the branches of the middle lobe. This course can be followed until it terminates in the pleural cavity In Fig. 459 we see this same course in oblique right anterior, and the position of the fistula is confirmed.

Encysted Pleurisy

Clinically, as well as radiologically, pleural processes may present an indefinite aspect that does not admit of a precise diagnosis, and consequently cause difficulty in a choice of treatment In these cases

the most common indirect exploration methods do not permit us to *differentiate clearly* between purely pleural processes and pleuropulmonary processes.

These difficulties are even greater when limited processes exist, and are so situated that their position in the parenchyma or in the pleura can not be defined.

Bronchography is a very valuable auxiliary for diagnosis, for it



Fig 458 Penetration of the opaque medium showing the existence of a fistulous course that connects the branches of the middle lobe with the pleural cavity (Cont)



Fig 459 The same case as in Figure 458, seen in right anterior oblique position

permits not only a direct study of the bronchial tree neighboring the process but *also indirectly points out the relations existing* between the parenchyma and the pleural processes. The following case demonstrates the value of contrast exploration in this type of lesion.

Three months previous to admission, the patient, 47 years old, had an acute attack of fever with profuse perspiration, depression, and

coughing. The doctor who examined him diagnosed left pleurisy. This process became worse and 15 days later a muco-purulent expectoration, developed with pain in the side, fever and very low spirits

A few days later the patient vomited a large quantity of pus and obtained some relief. However, as expectoration continued he consulted another physician, who ordered the chest plate which is shown in Fig 460 and reveals an opacity of the greater part of the left lung



Fig 460. Direct radiogram showing an opacity in the left lung field with a clear and curved lower border. (Cont)



Fig 461 Transverse position radiogram, showing the posterior position of the *opacity* and *its clear outlines* (Cont)

field with a clearly defined, curved lower outline In transverse position (Fig 461) it is evident that this opacity occupies the most posterior part of the chest and has a uniform density with a frank limit in its lower and anterior portion.

In view of these images, a complicated hydatid cyst was suspected, but laboratory tests did not confirm this supposition.

Bronchography showed a displacement of the upper lobe bronchial tree as well as that of the lower lobe. This complete forward repulsion led us to suspect an encysted pleural process that had previously ruptured into a bronchus but no communication actually existed between them (Fig. 462).

A large quantity of pus was obtained by pleural puncture and a culture revealed the presence of pneumococcus A sulfonamide solu-



Fig 462 Bronchogram showing the repulsion of the branches anteriorly, caused by encysted pleurisy (Cont)



Fig 463 Direct radiogram showing a slight shadow in the left lung field (Cont)



Fig 464. Bronchogram showing the return of arborization to its normal position (End)

tion was injected and immediate and continued improvement resulted. A few days later, lavage of the cavity was again carried out and one month later the patient had recovered completely. At that time direct radiogram (Fig. 463) revealed that the opacity in the left lung field had almost completely disappeared; only a soft veil re-

mained. Bronchogram 464 showed that the bronchial arborization had returned to its normal position.

Empyema

Purulent pleural collections do not characteristically modify the bronchographic image. This process causes the repulsion of the



Fig. 465 Direct radiogram showing a dense opacity of the left base (Cont.)



Fig 466 Bronchogram showing a normal conformation of the bronchial branches and a repulsion towards the middle arborization line.

peripheral branching and its withdrawal from the chest wall in the same manner as any liquid collection may do.

Bronchial exploration was carried out in a patient presenting a sub-acute lung picture with a dense opacity in the left lung case (Fig. 465) in order to rule out the possibility that the suppurated process might have had its origin in the lung parenchyma and also in order to rule out the presence of a hidden hydatid cyst.

The result of the exploration was conclusive for it proved that the bronchial tree showed no changes in the conformation of the branches nor of the foliage and that only their distribution was altered due to the repulsion of the arborization towards the middle line by the contents of the pleural cavity (Fig. 466).

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THIS BOOK

RADIOLOGIC EXPLORATION OF

The Bronchus

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